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Pile Driving.

The short paper on overdriven piles for a temporary highway bridge near Danville, Ill., which appeared in The Engineering Record of Feb. 17 of the current year, is suggestive of some features of pile driving as actually practiced which do not increase the carrying capacity of piles when subjected to the so-called "driving to refusal." The writer of pile-driving specifications probably considers in general that his provision for the driving of piles to refusal is a kind of clincher for the efficiency of the pile foundation which he is about to construct. There is an apprehension pretty generally prevailing that if a pile is not driven to that point where it refuses to go any further, or to the point where its motion is exceedingly small when repeatedly hit a heavy blow, its carrying capacity will be unsatisfactory or even dangerously low. As a matter of fact, where piles are driven under the direction of good judgment tempered by intelligent experience the driving of a pile may frequently be stopped not only short of refusal, but much short of that point, to great advantage. The illustration published in The Engineering Record to which reference is made above gives this observation telling emphasis.

The function of a pile hammer is not to drive a pile until it is split into pieces in its lower portions, but to give it such penetration into the material at the foundation site as will yield its maximum bearing capacity, which capacity is probably not exerted at the pile point in more than a majority of cases. When a pile penetrates a compact, tenacious earth, such as sand, gravel, hard clay, and other similar materials, it may, under skillful and careful driving, be brought to practical refusal without serious damage, but on the other hand it is probably not possible to drive any considerable number of piles to refusal under such circumstances without wrecking some of them, and sometimes even a large percentage. Any engineer who carefully observes the result of pile driving under such circumstances and who has had an extensive experience in such work, cannot fail to have observed that as piles move to a constantly decreasing amount under the impulse of the hammer, a minimum set will often be reached, after which the pile will continue to move somewhat more freely and perhaps with materially increased ease. The conclusion is thus too frequently reached that the hard stratum has been penetrated, causing the point to meet a softer substratum. All too often this phenomenon in pile-driving means that the lower portion of the stick has been wrecked in one way or another by overdriving. It may be that the pile has failed at a knot or that some local weakness has induced an oblique shear, or again, as has been a number of times demonstrated by withdrawing the pile, a cross-fracture may have occurred, with the splitting of the lower portion, so that the upper part has been driven down between the separated halves of that lower portion. Where material is sufficiently soft and the piles are long the point may "wander" to a surprising extent. In the latter case the lower portion of the pile instead of penetrating vertically the material into which it is driven is bent perhaps nearly at right angles to the upper portion and simply moves laterally into the material whose holding power is very small.

The cure for these difficulties is obviously one which can be indicated only by the aid of an intelligent judgment trained by extended experience acting upon the merits of each particular case. It is a matter which is not controlled by simple and exact laws. It is first necessary that the pile should be kept in motion vertically until the amount of skin friction, or skin friction added to reasonable point resistance, shall be great enough to carry the imposed load with sufficient margin of safety to make the foundation indefinitely safe and durable. There are cases where driving to refusal may properly be required, but there are probably more cases where that end should be carefully avoided. There are many foundation sites in what are called mud, particularly in tidal localities, where that mud attains a sufficiently tough consistency within the reach of a pile of reasonable length to enable it to carry 15 to 20 tons with perfect safety. Few things may be more misleading than the action of a pile when driven into material of that character, for every blow keeps it in motion with a set which, if introduced into any one of a number of standard formulas, would indicate a small carrying capacity for the pile. If, however, the pile be allowed to stand undisturbed for a few days, or perhaps for one day only, it will be found that a number of blows from a heavy hammer will be required to start it. The material during the period of rest will settle solidly into all the roughnesses of the pile surface, with the water largely squeezed out by the weight of the material, resulting in such a bond with the exterior surface of the stick as will hold it fast until the shock of the hammer has disturbed by shaking a relatively large zone of surrounding material, thus temporarily reducing the carrying capacity of the pile.

It is an unusually poor material in which a pile is driven 40 ft. or more that will not carry with entire safety any load required by ordinary foundation conditions. There are, of course, localities where this observation will not hold, but such sites are relatively few and fortunately do not often distress the engineer. When they are found, extraordinary measures such as great lengths of piles and increased numbers of them must be used or even resort may be made to some other type of foundation. In the main, however, the consistency of mud and soft clay is sufficiently dense to give satisfactory carrying capacity for 30 to 50 ft. penetration, although the pile is stopped far short of refusal.

Contracts for Public Work.

The letter from Mr. Davis, of the Reclamation Service, printed elsewhere in this issue, together with the article in the March 3 issue of this journal, to which the communication refers, again bring up the often-discussed conditions attending contract work on public undertakings. The numerous suits in State courts and the Court of Claims at Washington are proof positive that public contract work results in more litigation carried to courts of final jurisdiction than contract work for private parties. Consequently there is a manifest necessity for some improvement in the business methods controlling city, State and federal contracts, for such excessive litigation is in itself proof that private parties can attend to construction better than public officials. This does not mean in any sense that public officials cannot administer their duties as efficiently as men engaged in similar work for private parties, but it points out that the rules and regulations governing public contract work are probably imperfect and inflexible. While any immediate marked change in the rules is improbable, nevertheless it is well worth while to consider some of their imperfections. This can best be done by referring to some actual examples.

A large private corporation recently had occasion to let a contract for an important piece of work differing in several respects from anything previously attempted. The specifications regarding the finished work were very clear and explicit, and so drawn that there could be no question about the results desired. Inasmuch as it was an unusual undertaking, which had to be carried through as rapidly as possible, the specifications also outlined several methods of construction which would be acceptable to the company and also allowed bidders to suggest other methods, although reserving to the company the right to reject any not regarded with favor by it. The company compiled a list of every contracting firm in the country having a financial standing and experience warranting the belief that it could perform this work satisfactorily. This list was then investigated very carefully and reduced to perhaps fifteen or twenty firms, which were asked if they cared to consider undertaking such a contract. Those that replied affirmatively were sent the plans and specifications, which could be obtained by no other parties. This method, it will be observed, is the customary one on large private undertakings. In comparison with it the procedure for letting of public work is entirely different. Public opinion and the laws both strongly favor giving the award to the lowest bidder who can furnish the requisite sureties, irrespective of his financial reputation and experience. It is an open chance whether the contract will go to a reputable firm, desirous of completing the undertaking in a manner creditable to itself, or to a bidder whose career has been one long wrangle over extras claimed on grounds that are usually of the most trivial weight, however important they may appear to the man without engineering experience. These irresponsible bidders cannot participate in competitions for sound private companies, for the latter will give them no opportunity to submit tenders, and in consequence they are forced to look mainly to public work for a livelihood. Here they are a source of anxiety to the engineer and of unfair competition to the reputable bidder.

In the present state of public opinion regarding contracts for public work, the engineer has only one course left open to him. This is to hedge about his undertaking with every contract stipulation that he can imagine will enable him to keep out bad materials and workmanship and will advance the time of completion of the work. On this account the specifications for public work have become loaded down with requirements that seem extremely onerous to a contractor whose experience is confined wholly to private work. Such requirements, enforced by an incompetent engineer, may work hardship, but the competent engineer will be enabled to interpret them in such a way that a contractor who is willing to do work fairly will have no serious complaint to make. If there is any way to write specifications and contracts for public work better than they are now written, the engineer will be the first to welcome the information, but he will fight against any tendency to restrict the requirements to as few subjects as are covered by private contracts and specifications. To do this will make public work the happy hunting ground of every contracting highwayman in the country, and drive out the many reputable and financially strong firms now engaged in the business.

It must be acknowledged, however, that there is a feature of public contracting which is open to serious complaint. This is discrimination against the contractor on every occasion where specifications can be interpreted in different ways or when the engineer is given some latitude in his requirements. This discrimination is rarely due to the action of the chief engineer, but is the result of lack of experience on the part of the resident engineers and inspectors. Some contractors, warned by previous bitter experience, always begin their work with the apparent purpose of skinning it down as fine as the resident engineers will permit. Their previous undertakings of the same sort have convinced them that any apparent purpose to do otherwise would be interpreted as a sign of weakness and result in being held up for more than their contract obligations. It is a pretty good test of a young inspector's ability and judgment to carry through the initial work on a contract under such conditions without losing his temper or requiring anything but a reasonable compliance with specifications. Yet that is the course to be followed, and many engineers have laid the foundations for future success by adhering strictly to it, thereby gaining the respect of both their engineering superiors and the contractors whose work they have supervised. Inasmuch as unreasonable requirements by resident representatives are probably the most serious cause of complaint to-day by contractors, it is suggested that this feature of the work is probably more open to improvement than any other.

There is another defect in public works management which is also so serious as to deserve immediate reform. This is the habit of readvertising work without making any change whatever in the plans and specifications, when the lowest bidder happens to be a contractor of known irresponsibility. This is happening altogether too often, and is a great injustice to reputable contractors. These men make a thorough study of the plans and specifications, prepare a careful estimate of the cost of the work, engage sureties and submit a tender. This often costs them a considerable sum. When the bids are opened publicly the amount of their tender is known. Such information concerning the bid of a reputable company is worth a great deal of money to other contractors, and if the bids are all thrown out and the work readvertised, none of these reputable firms, submitting honestly prepared tenders in the first place, have any show of getting the work. Anybody can take seven to ten per cent. off the tenders of these experienced contractors, and then submit a bid which will probably cover the actual cost of the work, if well handled, and yield a small profit. Such readvertising would result in very serious complaint if done by private parties, but the contractor for public work is hardly in a position to make a vigorous protest, for by so doing he will incur the enmity of the employees of a public department which will probably have much more work to give out in the future.

Compulsory Municipal Sanitation.

The pollution of water by sewage and the purification of municipal water supplies are becoming very important in parts of this country, although there is considerable difference of opinion concerning methods of disposal and the extent to which large bodies of water, fresh or salt, can receive untreated sewage without a nuisance being caused. It is definitely known that some views previously held on the subject must be modified, but to what extent is still problematical. Under such circumstances friction is bound to occur when an attempt is made to compel any community to purify its sewage or otherwise dispose of it, by methods that do not find local approval. In England, where the Local Government Board exercises almost despotic authority on such matters, there is no harmony of opinion, and it is accordingly idle to expect it in the United States, where there is no central authority having power to prevent the construction of works which do not meet with its approval. It is true that a few States have commissions that must give approval to all plans of sewerage and sewage disposal, but the degree of supervision exercised by these bodies differs materially, and there is no agreement between them concerning satisfactory methods of disposal, according to the testimony of engineers who have had occasion to submit plans to the commissions of more than one State.

There is a noticeable tendency growing up in parts of the United States, where the conditions are favorable, for joint action concerning sewage disposal. The Metropolitan system in Boston and vicinity and the joint outfall sewer in northern New Jersey are the most important examples of such work. Such organizations of distinct cities and towns into a single district afford a solution of the sewage disposal problem that is often beyond the individual resources of some of the communities in the district. Such a case is presented in the Passaic River district in northern New Jersey. This river was formerly famous for its beauty, and its upper course is still attractive. The growth of Paterson, Passaic, Newark and other places along its lower course, all discharging sewage into its waters, and the use of the river as a receptacle for the sewage of more distant communities, has converted it into an open drain, which is closely rivaling the character of the Chicago River before the opening of the drainage canal. The stream is filthy, and it is generally admitted that sewage must be kept out of it if it is to be prevented from becoming a menace to health. The condition was recognized a number of years ago, and various commissions were organized under legislative action to solve the problem. None of them succeeded, for nominal reasons that need not be discussed at the present time. The real reason has been that the people of Paterson were deeply opposed to engaging in any trunk sewer enterprise in association with other cities and towns in the valley. The legislation up to the present time has all been so drawn as to compel the city to take part in such undertakings, and the very successful opposition it has maintained to the projects up to the present time is one of the most important lessons in contemporary sewage disposal affairs. Inasmuch as an agreement has now been reached between Paterson and the other parties to the pollution of the river as to future action, it is well to consider the result of all the years of bickering and wrangling over this serious problem.

The city of Paterson has never denied that it was desirable for its sewage to be kept out of the river, and of late has proposed to take it out at the earliest possible moment, provided all other sources of pollution were stopped at the same time. What the city has been objecting to so seriously was the determination of the Legislature, under the influence of the other communities in the valley, to compel the city to dispose of the sewage in one particular way. It would agree to keep the sewage out of the river and to purify it in a way acceptable to competent authorities on the subject, but until it had become convinced what was the best plan to follow it would fight to the bitter end against any attempt to interfere with its right to make up its own mind concerning its own business. So it has been fighting for years a winning fight, and has at last demonstrated to the other interested parties in the valley that it must have its way. It was announced in this journal some weeks ago that the city had engaged Mr. Allen Hazen to make an exhaustive study of its problem of sewage disposal, which is a very difficult one on account of the presence of large amounts of manufacturing waste liquors in the sewage. It has appropriated more money for this investigation than was previously appropriated for the engineering work on the joint trunk sewer project for the entire valley, and it has shown every indication of wishing to ascertain just what can be done with the city's sewage other than discharging it into a trunk sewer built by the whole valley. This disposition has made it entirely impossible for any further fight to be made to compel the city to enter the proposed joint outfall sewer project until Mr. Hazen's investigations are completed. Accordingly, a truce was patched up last week and no legislation concerning the pollution of the Passaic will be attempted until next fall. By that time the city will know whether or not it wishes to enter the joint sewer project, and if it decides to construct its own works it will not oppose any legislation for the construction of joint works for other communities in the district, provided it is relieved from any financial obligation for them.

This result is of much interest because it leaves the matter in precisely the situation it was before any attempt was made to force the city against its wishes into a joint undertaking. The long delay in accomplishing anything, the arousing of bitter antagonism between neighboring communities, and the useless expenditure of time and energy in wrangling, can be attributed to a determination to compel a city to do something in the way of sanitation that it did not wish to do. The lesson of this strife is that when a State attempts to compel a city to accomplish certain sanitary results it will do well to be content with specifying what these results are and not also specify how the results shall be accomplished. In this case the result desired was the removal of the city's sewage from the river and its disposal by some means that would not cause offense, an object that the State could reasonably expect to enforce. The further attempt of the Legislature to force the city to become associated in a repugnant alliance with its neighbors in an enterprise which it regarded, rightly or wrongly, as a great waste of money was contrary to the American spirit and has completely failed up to the present time. The Engineering Record has long held that a joint trunk sewer was the proper remedy for the sewerage conditions in the Passaic valley as a whole, but it has also been gratified to observe that the attempt to force the city of Paterson into the project against its wishes have been unsuccessful. The city is now getting expert advice on the subject of its sewage disposal, and if the remaining communities in the district wish to have any new strong arguments for their side of the subject they will do well to make an appropriation sufficient to enable the engineering work done for the Passaic Sewerage Commission to be completed in greater detail. The trunk sewer project was far greater than that which Paterson has in hand, and yet the city is paying considerably more money for its expert advice than the Commission paid for its technical investigations. Under the circumstances it will not be strange if Paterson can find enough unimportant details in the joint trunk project, as outlined up to the present time, to make it look quite sick to the average legislator without engineering knowledge. All the engineering work done for the joint outfall sewer was essentially of a preliminary nature, except the surveys and the outlining of the main project, and consequently subject to revision in detail.

The Electrification Problem of the New Haven Railroad.

The description of the electrical equipment of the portion of the New York, New Haven & Hartford R. R. west of Stamford, which is given elsewhere in this paper, deserves a few words of comment and explanation. Many people have considered it very strange that this company should install an alternating-current system connecting with the direct-current system of the New York Central road. At first sight it would appear that the logical procedure would be to use the same system as the Central, for the New Haven's tracks as far as Stamford are regarded by many people as physically, if not actually, forming a part of one suburban system converging to the Grand Central Station in New York. This is hardly a true view of the situation, however. Although the New Haven company has been running its trains into the Grand Central Station for many years, it does not follow that it will always do so, and, even should this practice be continued, the selection of an electrical equipment for the New Haven line could not properly be governed, although it might be influenced, by the New York Central installation. A glance at a railway map of Southern New England will show the reason for this.

The New Haven system is not a main line with branch feeders, such as traverse most parts of the country, but is a network of steam and trolley roads connecting towns close together. It is essentially a consolidation of lines, and its traffic is largely of short-haul character, resulting in congestion on very slight provocation. As a general proposition, the problem of operation is to get the most traffic over the line with the least expense. This problem is very different from that of long-haul traffic on a trunk line, able to handle many times the present business before additional tracks become necessary. Electric traction is eminently suited for such a situation. With the electric locomotive there is no boiler to limit the hauling capacity, and there is no need to strengthen bridges in order to carry great loads on driving wheels. It is only necessary to use two or more electric locomotives operated on the multiple-unit system to obtain enough power to pull out the drawbars of the cars, without overloading the roadbed or bridges. In short electric traction will render possible a considerable increase in traffic without increased track facilities, and will also permit an economical operation of frequent short local trains. In addition to these special conditions in Southern New England, the location of the New Haven system near tidewater or rivers is an ideal one for the cheap generation of power, which in itself is of much advantage in the electrical operation of railway lines.

Although the New Haven system is a collection of local railways, it also has an express traffic that must be provided for, and this introduces a special condition on electrification. While frequent light trains present problems familiar to the electric railway specialist, the load imposed on a power generation and transmission equipment by heavy express trains is quite different from the fairly steady load of a city railway. For this and other reasons hardly necessary to enumerate, the engineers of the New Haven company decided that the simplest method of delivering current from the power station to the locomotive was desirable. This problem was not to handle traffic for a short distance in and out of New York, but to handle trains between New York and New Haven, with possible extensions to Springfield to the north and Boston to the east. While it was necessary for them to adopt a system which would operate satisfactorily in connection with that of the New York Central's Electric Zone, it was also necessary to consider the traffic conditions of the New Haven road as a whole. In view of all these conditions, they decided that the alternating-current equipment was the best. It eliminated the complicated power distribution methods necessary for direct-current operation, avoided additional maintenance of way problems other than those of the very durable type of overhead construction that has been adopted, and still fitted in harmoniously with the equipment of the numerous trolley lines controlled by the company. It is understood that the company proposes to utilize these trolley properties in connection with a number of steam branches which do not serve very populous districts. By using alternating-current for these branches as they are electrified from time to time, it will be possible to operate main line trains over the branch lines whenever the conditions make it necessary.

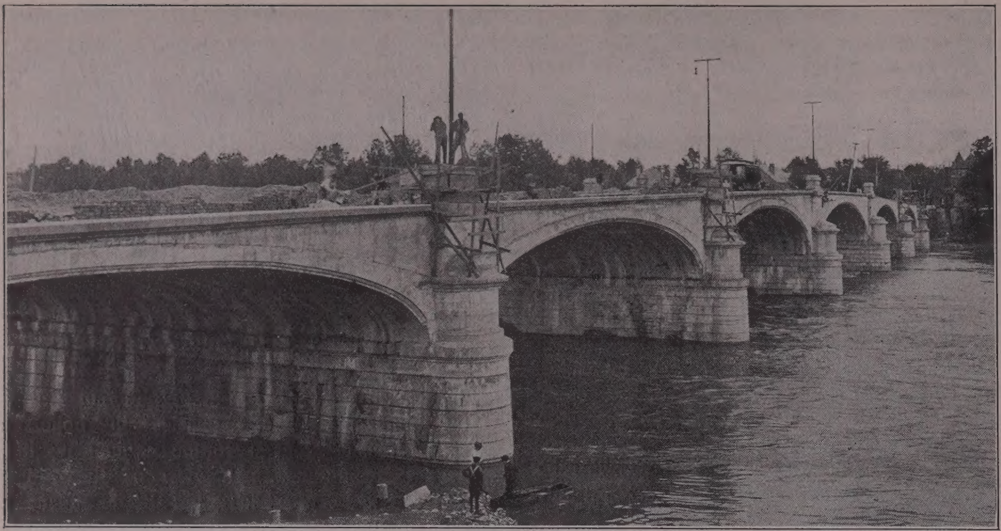
The technical details of the installation are so well explained in Mr. Lamme's article to which reference has already been made, that it is unnecessary to refer to them except in one particular. From the point of view of the designers of the equipment, the only feature presenting any trouble was the power station. Contrary to general belief the Westinghouse engineers had every confidence in their ability to produce satisfactory single-phase motors of large size, but the generating units required unusual study. While the installation as a whole will be one of exceptional interest and its operation will attract attention from many quarters, it is probable that its power station results will furnish the most important general lessons. Probably nobody expects that the design of locomotive will remain unchanged very long; it is bound to be altered as experience in its daily use is gained. It is certainly good enough to try thoroughly, however, and this is what the New Haven road will do. But nobody can tell what changes in traffic conditions electric operation will render advisable, and until these changes are discovered the broad power station problems must remain in abeyance, and reliance must be placed on the data obtained from urban and interurban roads.

Notes and Comment.

THE EDISON POWER STATION FIRE in San Francisco a short time ago emphasizes the importance of housing central station equipments in fire-resisting buildings. In view of the wide commercial use of electricity and the dependence placed for all classes of service on such stations, a suspension of current for even a short time has a considerable injurious effect on a station's business reputation. New stations are generally constructed with some regard to fire resistance, but the old wooden shacks formerly erected as station buildings were unfit for their purpose.

THE LABOR EXCLUSION BILL recently passed by the Maryland legislature and now before the Governor for his signature is even worse than was indicated in the note printed last wek. It declares that no contractor on public works shall employ any but registered voters without any exception, other than in the office force and technical assistants. It, therefore, becomes practically impossible, if the bill becomes a law, for a contractor to resist a strike or to push construction by putting on men from other States when the apparent available supply of registered voters is exhausted. Such an attempt to control the labor market at the expense of the great mass of taxpayers was probably never before made anywhere.

A TRADE-MARK DECISION has recently been rendered by the United States Circuit Court for the eastern division of the Northern District of Ohio which is of more than ordinary interest. The suit was brought by the Babcock & Wilcox Co. against the Aultman & Taylor Machinery Co. to protect its rights in its well-known trade-mark, which has stood for the highest grade of design and workmanship ever since the company was started. This trade-mark consists of the word "steam" accompanied by a representation of Hero's æolipile, and has become thoroughly identified with the Babcock & Wilcox Co. The court has accordingly enjoined the Aultman & Taylor Machinery Co. from directly or indirectly using, printing, publishing or putting into practice, or in any way counterfeiting or imitating this trade-mark or any like it. This decision must be a welcome one to the many manufacturers who have built up a business reputation based on a high quality of workmanship as well as excellence of design. Patents expire and an established article which was introduced under their protection can then be made by anyone, but a hall-mark of quality is so closely associated with the actual good will of a manufacturing business that any infringement of it is a serious matter. A trade-mark is an important indication of quality, and the determination of the Babcock & Wilcox Co. to protect theirs against any imitation deserves the hearty approval of the engineering public, which has learned to look upon a good many trade-marks as indisputable proofs of workmanship. If these trade-marks were to be imitated without objection on the part of their owners they would have no value in a short time.



Reinforced Concrete Bridge Across Miami River at Dayton, Ohio.

THE THIRD STREET REINFORCED CONCRETE BRIDGE, DAYTON, OHIO.

Third St., Dayton, Ohio, formerly crossed the Great Miami River at a height of 25 ft. above low water on a bridge with two covered wooden Burr truss spans and two iron spans, the former having two 12-ft. roadways and the latter having one 22-ft. roadway and two 5-ft. sidewalks. At the site the ordinary low water width of the river is about 300 ft. and the depth 2 or 3 ft. The river is subject to frequent rises, especially in the spring, but is generally low in the fall and early winter.

When it was determined to replace the bridge by one of a greater capacity an agreement was made with the Concrete-Steel Engineering Co., New York, to furnish complete plans and supervise the construction of the new bridge for the sum of $12,000. They accordingly designed a bridge of the Melan arch system with a total length of 710 ft. between abutments and a clear width of 62 ft. It comprises seven spans and is made symmetrical about the center of the 110-ft. middle span, which has a rise of 9.67 ft. and is flanked on each side by successive spans of 100 ft. with a rise of 11.30 ft., 90 ft. with a rise of 13.25 ft., and 80 ft. with a rise of 14.25 ft. The different spans are arranged so as to provide for a regular camber from the abutments to the middle of the bridge, and their dimensions involve varying thrusts which do not counter-balance each other, but bring the line of pressure outside of the middle thirds of the piers at the first footing courses, thus creating tension in the ends of the longer spans which is taken up by special steel reinforcement bars.

The stresses are calculated on the assumption that the dead loads are produced by the weight of the concrete at 150 lb. per cu. ft., filling at 120 lb. and pavement at 150 lb. per cu. ft. The roadway and sidewalks are proportioned for a live load of 150 lb. per sq. ft., and the roadway is proportioned for an additional concentrated load from a 40-ton electric car. The maximum unit stresses exclusive of temperature stresses allowed in the concrete are 500 lb. compression, 50 lb. tension, 75 lb. shear. The reinforcing steel ribs are proportioned to take the entire bending moment of the arch without being tressed more than 18,000 lb. per sq. in., and to have flange areas of not less than 0.0066 of the total area. These loads produce maximum thrusts of 89,700 lb. in the 80-ft. span, 103,300 lb. in the 90-ft. span, 110,450 in the 100-ft. span, and 119,600 lb. in the 110-ft. span.

The piers were unsymmetrically designed so that the line of pressure should come in the center of gravity of the base thus providing a uniform load on the foundations. This construction extended the toes so much that steel reinforcement bars were provided to take the tensile and shearing stress developed there. The foundations were carried in open caissons to a depth of 7 to 12 ft. below the bed of the river and the piers were built of thicknesses of 9, 10 and 11 ft. respectively at the springing line. The thickness of the arch ring varies from 19 in. to 25 in. and the distance between the crown of the arch and the crown of the roadway varies from 15½ to 17½ in.

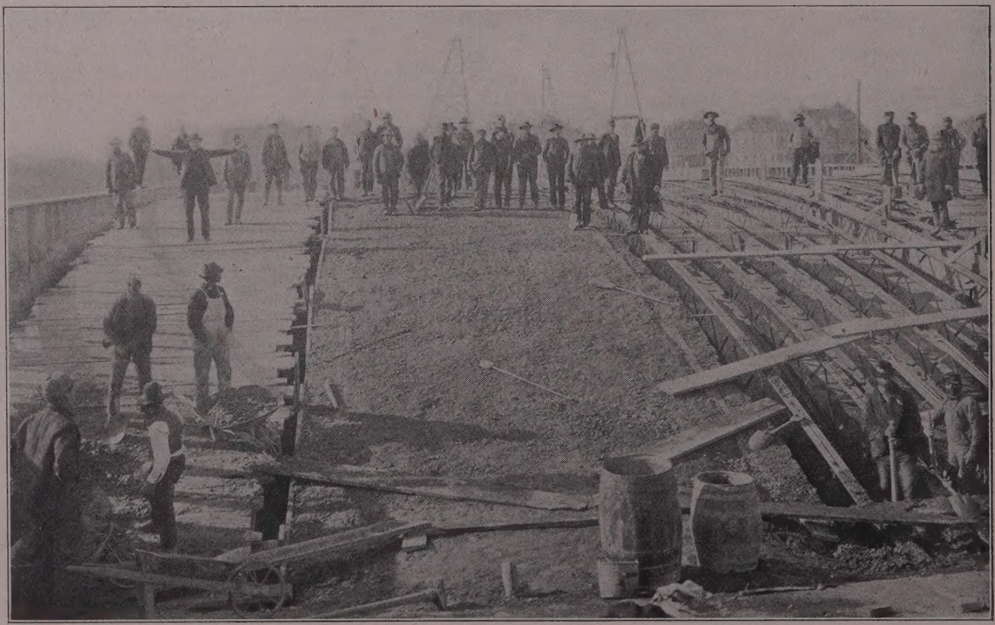
The arches are reinforced with lattice girders of corresponding depth spaced 34 in. apart on centers and each having four 3x3x5/16-in. flange angles except in the two end spans where they are 2½x2½x5/16 in. Each girder is made in three sections field riveted together, spliced continuously from span to span over the piers and well anchored at the piers and abutments.

The 10,200 cu. yd. of concrete in the piers, abutments and wing walls was made 1:3:7, the 530 yd. in the spandrel was made 1:3:6, and the 4,540 yd. in the arches, pedestals, balustrade and parapet wall was made 1:2:4, different grades being made with 2½-in., 2-in. and 1½-in. broken stone. In all there were used 16,800 barrels of cement. All concrete surfaces exposed to view or to the weather are finished with ½ in. of 1:2½ Portland cement mortar which was built with the concrete and thoroughly bonded into it. The upper surfaces of the arches and the inner surfaces of the spandrel walls were grouted with pure Portland cement, and after this was set hard were coated with ⅛-in. thick coal tar pitch.

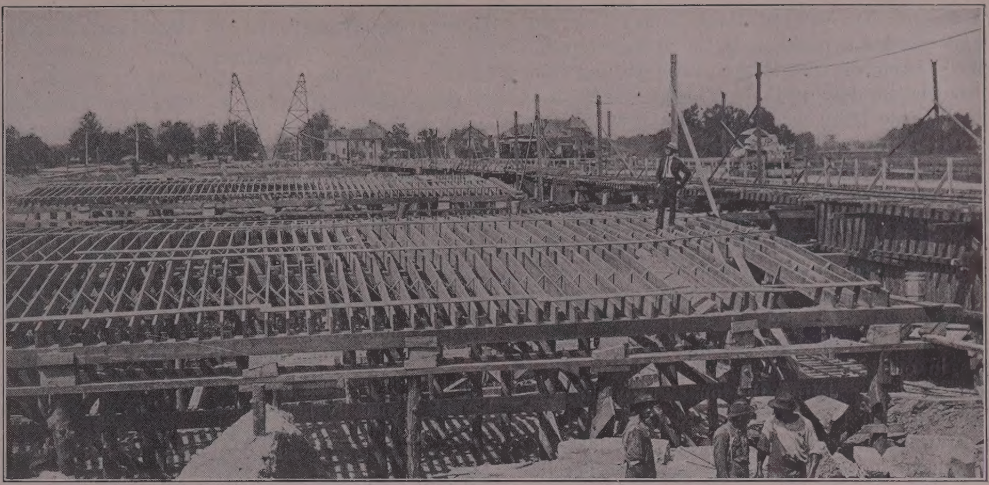
In order to maintain pedestrian, vehicular and street-car traffic during the construction of the bridge a temporary bridge was first built parallel to the old one and about 70 ft. away on centers up stream. It had an 18-ft. roadway supported on pile bents 15 ft. apart, except opposite the four channel spans where alternate pile bents were omitted and the 30-ft. spaces between them were spanned by sets of four 24-in. I-beams 32 ft. long, which thus provided openings for the passage of drift wood, etc. The sidewalk was cantilevered on alternate roadway floor beams 24 ft. long. The piles were driven by a 3,200-lb. drop hammer in 30-ft. leads, which with the engine was mounted on skids on top of the piles and advanced as they were driven. The bridge was commenced April 11, 1905, and the first car crossed it May 20. Bids for the structure varied from $6,000 to $26,272, and the contract was awarded to the lowest bidder for the permanent structure, who did all of the work here described.

On account of the danger feared from floods the construction plant was located as much as possible on high ground, the street-car track being moved as far back as possible to allow room for the contractors' plant at one end of the bridge. Two 930-ft. span Lambert cableways parallel with the bridge were installed, one 25 ft. each side of the bridge axis, and extended sufficiently beyond the abutments to provide comfortable loading spaces at both ends. The towers were 70 ft. high and the 2-in. cables of extra strong crucible steel had a deflection of about 35 ft. at the center point when loaded. The carriage, hoisting tackle and load required about 15 ft., and thus left a clearance of about 15 ft. The cables were designed for a working load of seven tons, which was occasionally reached, but the average load was only 3 or 4 tons.

A large part of the materials in the superstructure and substructure of the old bridge was removed by cableways, which also handled the material excavated for the piers on the east



View Showing Lattice Girder Reinforcement and Portion of Concrete in Place.



Falsework for Arches in Place on Pile Bents.

end of the bridge and distributed it where necessary for filling around the cofferdams. They also handled the pile driver, pumps, engines and other machinery, and over 1,000,000 ft. of lumber for the falsework and concrete moulds, which was delivered as received in wagon load lots. They unloaded from the wagons and delivered where required all the steel reinforcement girders and transferred all of the concrete from the mixer to the points where it was used at the rate of about 400 cu. yd. 450 ft. in 10 hr., at a cost of less than 2 cents per cu. yd.

Sand and gravel were excavated from a pit 4½ miles from the bridge site and were screened by a machine designed by the contractors, built by the Jeffrey Manufacturing Co., Columbus, Ohio, and operated by an electric motor. The machine, attended by one motorman and five laborers to handle the cars, and two trainmen and switchmen, had a capacity of 400 cu. yd. in 10 hr., and loaded directly into six 10-yd. dump cars of special design to admit of their transit direct to the bridge side over the sharp curves of the city railway track. With this equipment the cost of excavating, loading, screening and delivering the sand and gravel to the storage bins at the bridge was less than 50 cents per cu. yd.

The sand and gravel was delivered to hopper bottom storage bins built in the temporary bridge and arranged so that cars from the street railway tracks could be switched over them and fill them. The bins discharged through two-way chutes into 2-yd. center dump steel cars on a double track underneath the bins at an elevation of 4 ft. above low water. These cars were alternately hauled by a cableway up an inclined plane which followed the surface of the ground to the top of the levee and thence was carried on timber bents of a maximum height of 35 ft. to the concrete mixer, where they discharged by gravity into the feeding hoppers.

By this arrangement 400 cu. yd. of gravel and broken stone and the corresponding quantities of sand and cement could be delivered in 10 hr. to the hoppers, which were provided with automatic feeding devices delivering the required proportions of the different materials to a Drake duplex continuous concrete mixer. This machine had a capacity of 400 cu, yd. in 10 hr., and its discharge was arranged so that half of the concrete was delivered at the mixer and the other half carried 50 ft. away by a belt conveyor at right angles to the street. The concrete was received at each of these points in 2-yd. bottom dump steel buckets, one of which was being filled while the other was being carried by the cableway to the point where it was required. The cement was stored in a shed adjacent to the mixer, and it was elevated in bags by a machine driven by the mixer engine. The concrete plant was operated at a daily cost of $27 for 400 cu. yd. of concrete mixed in 10 hr., and required the services of 14 men in all, two at the sand and gravel bin chutes, one at the feed chute, one hauling machine engine man, one concrete engine man, one concrete grader man, 4 cement handlers, and 4 concrete discharge handlers.

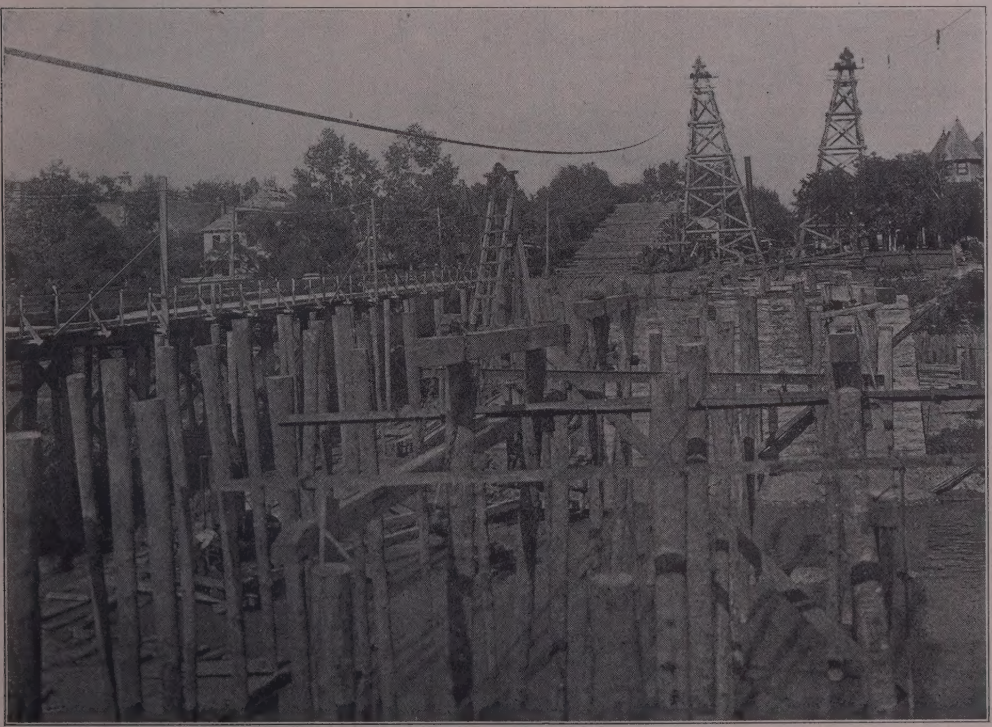
The falsework was supported on transverse bents 11 ft. apart, each of which had nine piles driven by a drop hammer, cut off about 3 ft. below the arches and capped with 4x12-in. timber on which were pairs of wedges supporting a 10x12-in. upper cap carrying 64 lines of 2x12-in. longitudinal stringers 12 in. apart on centers. To these stringers were fastened strips cut to conform to the arch curve and lagged with transverse 6x1-in. planed and matched boards. In the four channel spans some of the pile bents were omitted and the wide spaces thus left for the passage of flood and drift were spanned by timbers taken from the old bridge, above which the falsework was uniform with that in the rest of the bridge. As some doubt was felt concerning the strength of these old timbers they were additionally supported by intermediate vertical posts seated on sills in the river bed which, owing to the fortunate continuance of low water, were placed without trouble and were not disturbed by freshets. The arch centers were framed for a rise exceeding that designed for the finished structure by amounts equal to one eight hundredth part of each arch span.

Inside the cofferdams moulds for the piers were built with dressed 2-in. tongue and groove planks carefully braced and plastered on the inner surfaces with plaster of paris covered with a soap wash to prevent the adhesion of the concrete. The concrete in the piers was placed in 6 to 8-in. layers, well rammed and reinforced with Thacher bars. The footings, 4 ft. thick, placed continuously and rammed in 6 to 8-in. layers, were each completed in one day. The tops of the piers were finished to a A shape so as to form skew backs for the arch rings. The abutment concrete was placed in inclined layers as nearly as possible perpendicular to the arch thrust.

The arches were concreted in longitudinal strips, the center one being done first so as to leave exposed two of the steel girders on each side directly under the cableways. The concreting was commenced simultaneously at the skew backs on both sides of the arch, and when it had progressed some distance it was also commenced at the crown and carried forward to meet the skew back portions at the haunches. The work was continued uninterruptedly for each section until it was completed. The sections were separated by longitudinal forms placed midway between the steel girders.

The cableway was operated for the delivery of the concrete by means of a telephone system. The engine man wore a receiver fastened to his ear and directions were transmitted to him from men stationed in booths located at successive points on the temporary bridge. These signal men were near enough to receive orders from the foreman of the spreading gangs. The roadway was leveled up over the arches with gravel from the river beds delivered by wagons.

After two arches had been filled and the concrete in them was more than 28 days old, the wedges between the upper caps of the pile bents were loosened and a slight settlement was observed in the first arch which, however, regained its original shape after the wedges in the next span were loosened so that no final settlement was perceptible in the end arch, although there was a small settlement in the center arch. None of the centers were struck until after the two spans next ahead were covered with gravel near-



Construction of Pile Bents for Supporting Falsework.

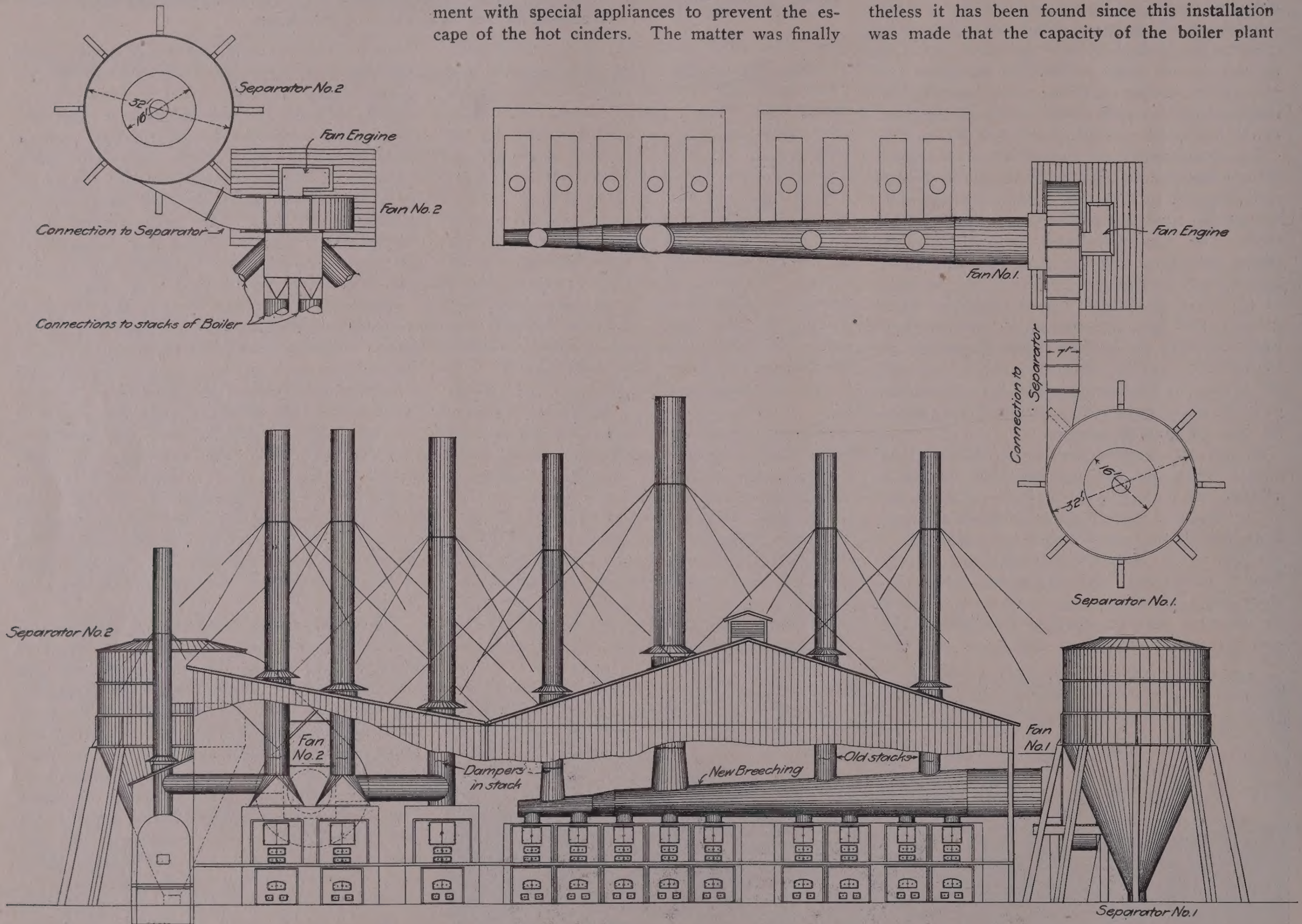
ly up to the required level. Concreting was commenced August 25, 1904, the arches were finished December 15, and the gravel fill was completed by the last of January, 1905. As soon as possible the track was laid and the street railway traffic carried over the new bridge and the temporary bridge was removed. Afterwards the wagon traffic was diverted to the Fifth St. bridge while the paving was completed here and the bridge was opened to general traffic in June, 1905.

The coping and balustrades were moulded in a shed where they were kept wet for 10 days, and after three or four weeks were removed to the open air. One man could make about 30 balusters in one day in a wooden mould in which they were tamped from the top. The coping was moulded with the upper surface down and the separate pieces were laid, like cut stone masonry, in cement mortar, the vertical joints being left open. After the railing was set it was cleaned and washed. All cement was furnished by the Castalia Portland Cement Co., Castalia, Ohio. The cement was all tested at the mills and the bins were then sealed and reserved for 28 days or more until the cement was shipped to the bridge.

The bridge was built under the direction of Mr. G. R. Stattelmann, resident engineer, and Mr. F. M. Turner, city engineer, at a total cost of about $184,600, including property damages, inspection, supervision, etc. Twelve bids for the work were received which varied from $179,600 to $340,000, the contract being awarded to the lowest bidder, Mr. Charles H. Hogland, Dayton. The moulded blocks were furnished by the National Art Stone Co., Dayton, Ohio, Mr. Karl Bracher, manager.

Cinder Separation in a Portland Power Station.

The power station of the Portland Consolidated Ry. Co., at East Portland, Ore., has a number of boilers which use saw mill refuse for fuel. The cinders belched forth from the stacks of these boilers were sometimes carried a distance of half a mile from the plant, where they caused annoyance by collecting on sidewalks and on clothes hung out to dry. Nearer the station the trouble was more pronounced, and the Inman-Poulsen Lumber Co., having a mill adjoining the power station, has lost thousands of dollars through the refusal of inspectors to accept lumber blackened by hot cinders which dropped on it. The railway company recognized that the conditions must be improved, but was at loss what to do except to install a new boiler equipment with special appliances to prevent the escape of the hot cinders. The matter was finally submitted to the W. G. McPherson Co., of Portland, which has solved the problem in an unusual manner by using induced draft and enormous separators.



Induced Draft and Cinder Separating Equipment for Boilers Burning Saw-Mill Refuse.

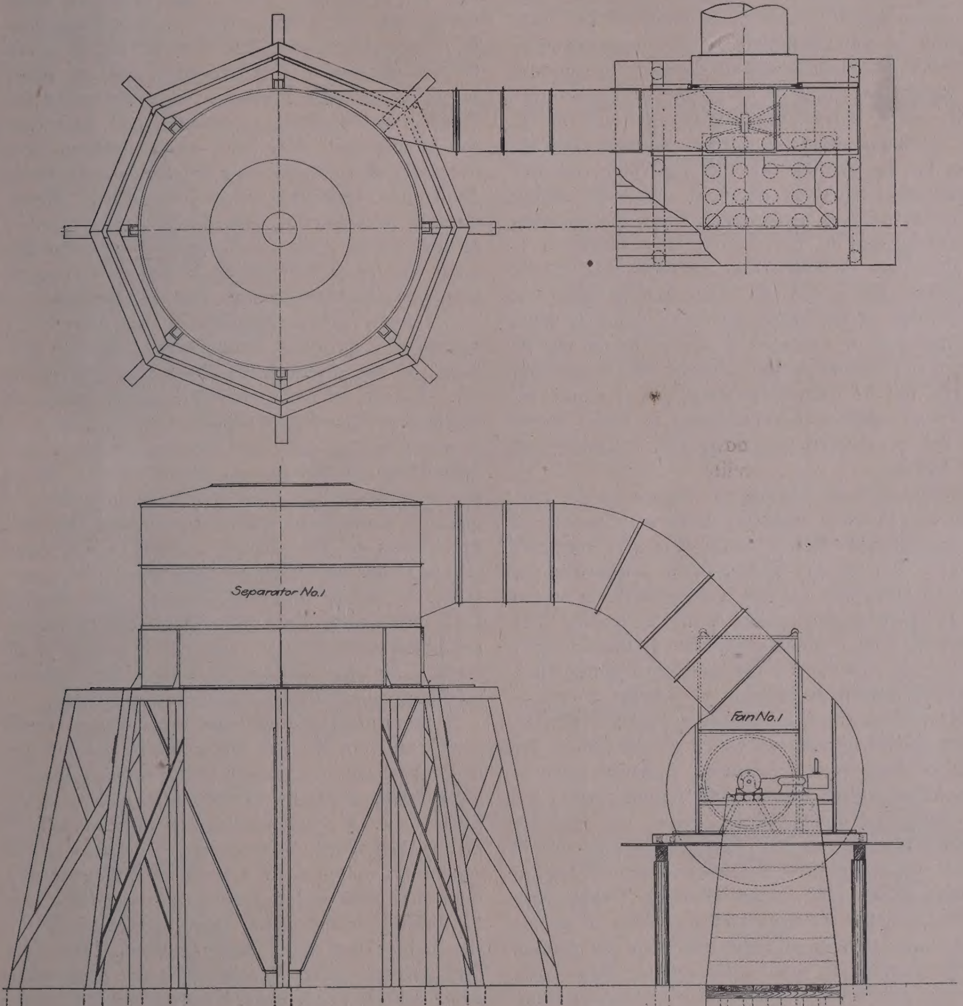
Before finally determining the sizes of the various parts of the plant, the McPherson Co. made a number of large model separators of transparent celluloid sheets, by which the operation of the apparatus could be carefully studied. When the action of the separators was definitely determined in this manner, the plant was designed along the lines shown in the accompanying drawings. There are two separate plants, one of nine and the other of four boilers. The boilers in each group are connected by suitable breeching with an induced draft fan 20 ft. in diameter, while dampers are provided in the old stacks by which the latter can be closed while the new equipment is running. The fan draws the smoke and cinders from the boilers and forces it into an enormous separator like that used for catching shavings in saw mills. When the smoke and cinders enter the separator they take a whirling motion and the cinders, being heavy, gradually drop in a spiral path to the bottom of the separator, whence they are taken on a conveyor to the furnaces to be burned. The smoke having thus been freed entirely of cinders escapes at a comparatively low velocity through the top of the separator into the open air.

Although the action of the plant has been watched by interested parties using strong field glasses, it has been impossible to observe the slightest trace of cinders escaping with the smoke. Fuel is very cheap, and accordingly economy in its use was not particularly important. Nevertheless it has been found since this installation was made that the capacity of the boiler plant was materially increased. Another advantage which was apparent immediately after the separators were put in operation was the absolute uniformity in the draft, which makes the management of the boilers easier than before.

The Septic Sewage Disposal System which the Ontario Board of Public Health has approved for use in Toronto is estimated to cost about $2,385,000. The plans prepared by City Engineer Rust provide for intercepting sewers with a capacity of 100,000,000 imp. gal. per day, septic tanks of 31,250,000 gal. capacity, a pumping plant of 37,500,000 gal. capacity, forcing the septic sewage through a main of 25,000,000 gal. capacity to filter beds for final treatment. The septic tanks cover 16½ acres, are 7 ft. deep, and one-fifth of them are intended for reserve.

Garbage and Refuse Disposal at Columbus, O.

Last summer, at the request of the Board of Public Service of Columbus, O., Mr. Rudolph Hering, of New York, made a personal investigation of several European and American garbage disposal works. In a report made last September he stated that the best plan for the city to pursue would be to collect both the garbage and general rubbish and to deliver both materials to a locality where, after mixing, they could be incinerated. The problem of collecting and disposing of these materials in Columbus has been an important one for some time, and shortly after the receipt of Mr. Hering's report the City Council asked the Board for "plans, specifications and an estimate of cost for erecting a crematory or providing other means for disposing of the garbage and refuse." Mr. John H. Gregory, principal assistant engineer of the Board, was assigned to the study of the subject and a short time ago submitted a voluminous report from which the following notes have been prepared:



Separator for Cinders at Power Plant of Portland Consolidated Ry.

Owing to the extensive use of natural gas for domestic purposes, and to a more limited extent for power, the output of ashes in Columbus is far less than in a city in which natural gas is not available. No ashes are collected by the city. Domestic ashes are removed at the expense of the householders by scavengers, licensed by the Board of Health, who haul the ashes either to dumps or to low land for use as filling. Ashes from office buildings, institutions, hotels, industrial establishments, etc., are in general similarly removed and dumped at the expense of the producer. Where the ashes have, however, a large percentage of hard clinker and a correspondingly small percentage of soft ash, they have a market value, being purchased by contractors for use under granolithic sidewalks, and the demand is in excess of the supply. The total amount of domestic ashes produced in 1905 is estimated at 64,000 tons.

In 1896, the city made a contract with the Columbus Sanitary Works Co., for the collecton and final disposal of garbage and dead animals, for a period of 10 years. This contract will expire on April 1, 1906. The company collects the garbage in wagons and hauls it to a railway siding where the iron tanks are removed from the wagons and loaded on cars. The cars are hauled 4½ miles to disposal works operated on the reduction process, where dead animals are also received. The grease and the tankage resulting from the process have been sold. The consideration paid by the city has been $15,800 per year. In 1904 the garbage transported to the reduction works is reported at 16,221 tons. The collection and transportation alone of this amount must have cost upwards of $20,000. Assuming the population of Columbus in 1905 at about 160,000, it is evident that, wtih an annual payment of $15,800, the cost of collection and disposal is less than $0.10 per capita per year, an exceedingly low figure. The amount of garbage at present is estimated at 17,600 tons per year.

At present the wood, paper, rags, bottles and other rubbish, oftentimes mixed with a considerable quantity of manure, is removed at the expense of the householders by scavengers who cart it to public dumps, set apart by the city, where rough sorting and picking is done by such as wish. A considerable proportion is dropped surreptitiously by the roadside to save haul. Large amounts are thrown by the householders into the streets and alleys. The total amount is estimated at 8,000 tons a year and a considerable amount is put into garbage receptacles.

The demand for cinders is such, and the opportunities for dumping clean ashes so frequent, that their removal for the present is not a serious burden on the citizens, Mr. Gregory states, and the consideration of a municipal service for ashes from residences may be postponed. Ashes should, however, be required to be free from garbage and rubbish whatever their final disposal.

From a sanitary point of view the garbage is the most important of the wastes. The major part of the cost of garbage disposal is expended on the collection, and no system of final disposal can be considered without taking into account the cost of transportation. The cost of haul, that is, the cost of carrying the load from the collection district to the point of delivery and returning empty, exclusive of the time in making collections, will amount to about $0.30 per ton-mile.

The city may collect the garbage by its own employees or through a contractor, whatever the method of final disposal. If the collections are made by contract, a suitable equipment to prevent street nuisance should be required, and the frequency of collections in the various districts should be specified and rigidly enforced. If the collections are made by the city employees, an equipment of wagons and horses, stable accommodations, etc., must be provided. The practice of working with hired teams, followed in the Street Cleaning Department, will not be satisfactory, as the service is nearly continuous and men must be retained on routes or in districts with which they are familiar.

It is in the thoroughness and regularity of the collection that the garbage matter comes close to the people, and Mr. Gregory insists that the man on the cart can make or mar the system. Under the contract system the driver is not individually answerable to the municipal authorities, a condition which is essential to the avoidance of friction. It cannot be denied, however, that the cost of collection through municipal employees will be greater than when done by a contractor, but the tendency under the contract system to increase the tonnage per man is not conducive to a thorough or efficient service.

Though rubbish is not so objectionable as garbage, in order to bring to an end the present unsatisfactory conditions, Mr. Gregory believes its collection and removal should be undertaken by the city through its own employees. With rubbish collected by the municipality the city's expenditure will be much increased, an expense which will be apparent but not real, transferred as it is from the individual, and the results will justify the cost. There are cases, however, in which the handling of rubbish might result in relieving the individual of a duty for which the public should not be made responsible. Many manufacturing concerns produce wastes, the disposal of which would be a burden not rightfully to be imposed on the public.

In England separate collections of ashes, garbage and rubbish are not made, but conditions in Columbus are so different that it is imperative, Mr. Gregory says, for the garbage and rubbish to be collected separately whatever the method of disposal of either. The duty of the householders and others to provide suitable receptacles and to place them properly, should be defined and enforced, and failure to make the desired separations penalized.

The idea of total destruction of organic matter in refuse is attractive to the medical mind, and the plan of incineration has become almost universal in England. The success attained there by the destructor is due in large part to the peculiar fitness of the refuse of English towns for the process. No house separation of waste is made, ashes, garbage and rubbish being deposited together, and hence not even the ash is clean enough to make it fit for filling. The use of open grates is almost universal and the ashes resulting therefrom are very rich in coal (35 per cent.). The percentage of wet animal and vegetable food waste in the refuse is very small. It has been conclusively shown in England that refuse destructors, located in crowded districts, may be conducted without the emission of odors, or other objectionabe features; the condition for satisfactory operation being that all gases of combustion must have been raised to a temperature of not less than 1,700 deg. F.

Experience in the United States with cremation has been rather unfortunate in many cases, both through the failure to recognize conditions unfavorable to the operation of certain types of furnaces, successful elsewhere, and through aggressive exploitation by the manufacturers of several poorly designed and constructed furnaces.

The absence of coal ashes, so large a part of the combined refuse in cities outside the natural gas districts, which would not be delivered to a crematory in Columbus, gives the local refuse a totally different character. Instead of constituting but about 8 per cent. of the combined waste which would be delivered to a destructor in England, the garbage and dead animals in Columbus will reach 65 or 70 per cent.; 70 to 75 per cent. of the garbage will be water, and the calorific value of the remainder will be so low that the garbage cannot be consumed without previous drying or the addition of fuel.

In the English reports the term garbage is used to cover paper, straw, and other fibrous material, as well as the animal and vegetable food waste, to which the name is limited in this report. The average percentages in the total amount of ash-pit refuse in London are stated by Russell as follows: Vegetable, 4.6; paper, 4.3; fibrous material, 3.2; bones and offal, 0.5; total garbage, 12.6. The food waste constitutes 40.5 per cent. of the matter termed garbage, or 5.1 per cent. of the combined ash-pit refuse. This matter, having been dried by contact with the ashes, will not contain the large amount of water found in the Columbus garbage. Large dead animals are not burned as a rule in the English destructors.

The constituents of the approximate average refuse handled in London destructors, as stated by Mr. Hering, and those which would be delivered for cremation in Columbus, separated by the ordinary method, into water, combustible and non-combustible, are estimated in tons per annum per 1,000 population in the accompanying table.

WATER AND COMBUSTIBLE AND NON-COMBUSTIBLE MATERIAL IN LONDON AND COLUMBUS GARBAGE.

	London.			Columbus.		
	Water.	Com.	Non-Com.	Water.	Com.	Non-Com.
Ashes	—	56	136	—	—	—
Garbage	22	12	2	82.5	22	5.5
Rubbish ...	—	10	2	—	42.5	7.5
Total ...	22	78	140	82.5	64.5	13.0
Per cent....	9.2	32.5	58.3	51.6	40.3	8.1

The term combustible is used in the table in a somewhat misleading sense, being the portion which will burn, rather than the chemical elements combining with the oxygen to produce heat. The English combustible consists principally of carbon, the Columbus combustible principally of cellulose, etc., having a much lower fuel value. It cannot be promised that the Columbus combined refuse will be by itself combustible without some system of previous drying or otherwise removing the water from the garbage.

The calorific value of the combined refuse, garbage, dead animals and rubbish, of which a crematory in Columbus must dispose, will not average above 2,000 B.t.u. per pound, and the total amount of water will amount to about 0.8 lb. per pound of refuse. The proportion of water will run much higher than this in the summer months and the calorific value of the refuse will be correspondingly reduced. In burning this low class of fuel a larger percentage of excess of air will be required than with a good fuel, and it is probable that more than 100 per cent. excess of air will be required rather than less. With 100 per cent. excess of air with perfect combustion and with no allowance for losses by radiation, the maximum furnace temperature possible is 1,100 deg. F. By extracting 25 per cent. of the water before burning, the theoretical temperature would be increased to 1,450 deg. F., which is still much below that temperature to which it is desirable to heat the gases, to prevent any possible emanation of noxious fumes. Mr. Gregory is therefore of the opinion that additional fuel must be burned in order to reach the desired furnace temperatures, providing that the garbage is not previously dried out by the waste heat from the furnace gases, the expense of which treatment might be greater than the cost of additional fuel.

In the cremation of Columbus refuse, without considering radiation, losses in ashes, leakage of air and other losses, the heat in the gases above about 500 deg. F., would be available for the evaporation of water in boilers. These losses are so indeterminate that it is difficult to figure the amount of water that could be evaporated. It is, however, merely a matter of adding sufficient fuel to the combined refuse to get any desired evaporation, but by burning this fuel separately a better evaporation could be obtained. Without adding more fuel than is necessary to bring the products of combustion to the desired temperature, it is unlikely that an evaporation of more than 0.5 lb. of steam per pound of refuse can be obtained. The value of the steam produced annually from the burning of 100 tons of mixed refuse per 24 hours at a crematory in Columbus would be about $2,772, but in order to produce this it would require an additional expenditure of about $2,250 for labor necessary for firing and attendance at the boilers.

Although it is possible to dispose of the garbage by reduction without causing a nuisance and at less cost than by cremation, it is Mr. Gregory's opinion that the city will be better satisfied in the end to build and operate a crematory, in which all the garbage and rubbish would be burned. The prevention of a possible nuisance is then directly under the control of the municipal authorities. Inasmuch as it is possible to operate a crematory without causing offense, a location for the plant should be selected which would reduce the cost of haul to a minimum. Sufficient ground should be acquired to provide dumping space for the ashes for many years to come. On this site should also be located the stables and wagon sheds, and it would be desirable to provide accommodations for the Street Cleaning Department.

In Columbus as elsewhere a number of people gain more or less of their livelihood by picking at the dumps. In some cities, notably New York, Boston and Buffalo, the rubbish instead of being hauled to the dumps, is delivered to an incinerator, where it is systematically sorted, the salable portions removed and the residue burned. Though not so objectionable as the putrescible garbage, no part of the rubbish makes a satisfactory filling, and the difficulties of obtaining low land in or near Columbus for this purpose will increase with the growth of the city. In case a crematory for the garbage is installed in Columbus, the whole, or at least the unsalable parts of the rubbish, should be burned with the garbage. If the rubbish is sorted, the removal of the salable parts will reduce the fuel value of the mixture of garbage and rubbish which would be burned, and the loss must be made good by additional fuel.

This report by Mr. Gregory was submitted to Mr. Hering, who has advised the Board of Public Service that he is heartily in accord with the recommendations. He points out that whether or not Mr. Gregory has corectly estimated the quantities of garbage and rubbish of Columbus it does not seriously affect the present purpose, as any moderate over or under-estimate would not affect the proposed work sufficiently to alter the recommendations. It is well, however, to use liberal figures, as the city will sooner or later grow up to them.

Regarding the recommendations for improving the system of collecting the city's refuse, it has been the experience that with a good organization, municipal collection is much more satisfactory to the community than collection by contractors, to whom the financial consideration is uppermost, while sanitary considerations control the work in the first order if the city engages in it. Mr. Hering is strongly of the opinion that the city should also collect all the rubbish.

Mr. Gregory's figures indicate a doubt as to whether it will be more economical to dry the garbage before it enters the furnace or to add fuel for combustion after it has been cast upon the grates. Mr. Hering says it is not essential to remove this doubt before an answer is given to this question. It is necessary now to make provision for both processes when designing the furnace, which provision does not add materially to the expense. Nor is a prior decision now necessary as to whether or not the heat resulting from the combustion shall be utilized. Means must be provided for whatever power is required at the works, and it is proper to arrange the plant in such a manner as to utilize, so far as practicable, whatever heat may be available.

The many refuse furnaces in England which successfully produce steam give sufficient evidence of the practicability thereof in that country. Instead of using domestic ashes, which in England contain a large amount of unburned coal, it would be necessary in Columbus to add a corresponding amount of fuel, either as coal, oil or gas, to produce the same result, because the expense in Columbus of hauling domestic and factory ashes to the furnace instead of to near dumps is not warranted by their small fuel value. It should not be forgotten, however, Mr. Hering adds, that such heat utilization must be but a secondary consideration, and not be expected to yield a revenue sufficient to reduce the expense otherwise necessary for burning the garbage.

If the refuse and garbage are collected separately, much of the free water can be drained out of the garbage, particularly in the summer season, after dumping at the works and before entering the furnace. A corresponding fuel value of the rubbish is thus saved. The wetness of garbage, which sometimes amounts to a complete filling of the interstices with water, requires a water-tight cart of different construction than one required for the lighter and more bulky rubbish. The fact that garbage must be collected quite frequently, while rubbish needs much less frequent collection, furnishes another reason why a separate collection should be preferred.

The detailed estimates of the cost of garbage and refuse collection and disposal, prepared by Mr. Gregory, were gone over by Mr. Hering very carefully and approved by him. He summarizes them as follows:

Construction and equipment for separately collecting garbage and rubbish and delivering in wagons not more than one mile from the capitol	$116,050.00
Crematory with land and equipment to consume 175 tons in 24 hours	168,300.00
Construction expenses for night soil disposal	5,500.00
Total cost of construction and equipment	$289,850.00
Operating expenses for 1907, including fixed charges	$62,259.00
($2.208 per ton, or $0.354 per capita.)	
Operating expenses for 1907, including fixed charges	44,404.00
($1.574 per ton, or $0.252 per capita.)	
Operating expenses for 1907, including fixed charges	1,605.00
($0.0125 per cu. ft., or $0.009 per capita.)	
Total operating expenses for 1907, including fixed charges	108,268.00
Total operating expenses for 1907, per ton	4.16
Total operating expenses for 1907, per capita	0.62

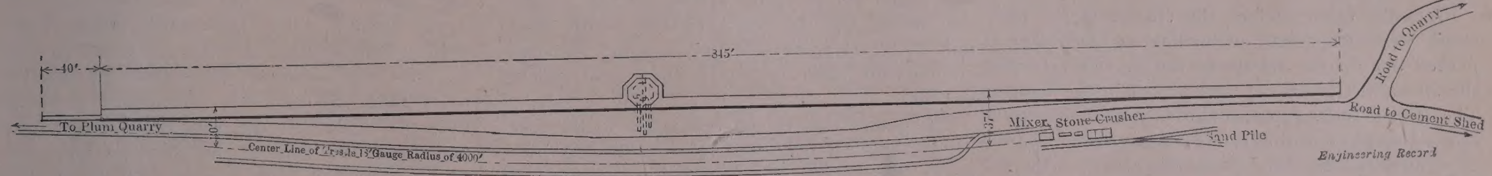
The Construction of the Trap Falls Dam, Bridgeport, Conn.

The Trap Falls dam is a part of the water supply system of Bridgeport, Conn., a city with a population of about 85,000. The Trap Falls reservoir was built by the Bridgeport Hydraulic Co., eight miles from the city, to be used as a storage basin, with Beaver Dam, one mile below, as a distribution center, and Far Mill River, three miles above, as a feeder, connected with it by a 30-in. pipe line. This pipe discharges a maximum of 22,000,000 gal. in 24 hours. The site is a natural basin on three sides, and on the fourth is the dam of cyclopean masonry, 900 ft. long, with a maximum height of 48 ft. This will form a basin approximately one mile in diameter and 236 acres in area, with a capacity when full of 1,400,000,000 gal. Its surface elevation is 302 ft. above mean high water in Bridgeport Harbor.

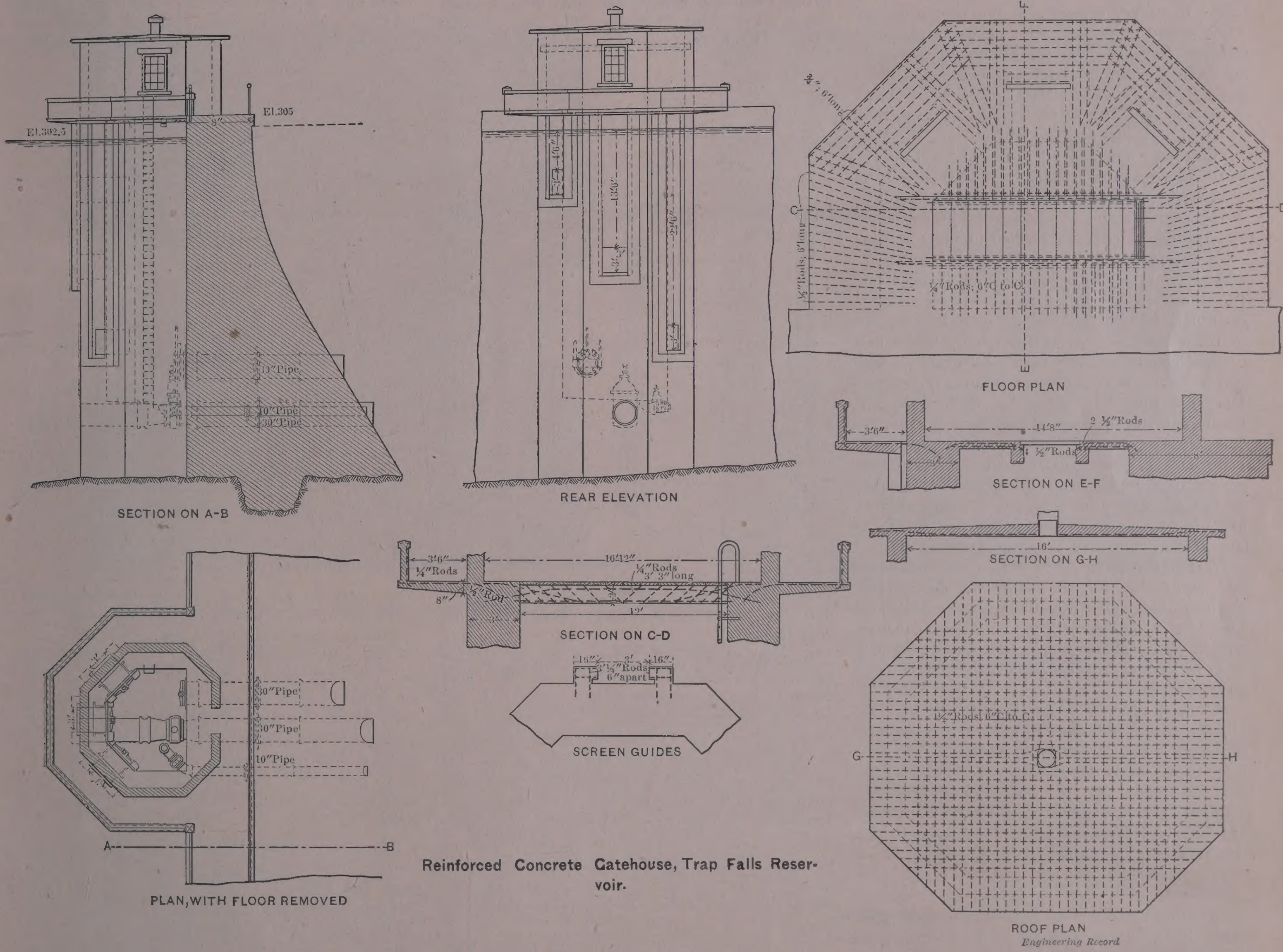
The total area was a dense woodland overgrown with a heavy mass of underbrush. The bottom for the most part is fine clean sand, but an area of 50 acres was covered with a kind of peat in the process of formation, the depth in different parts varying from 6 in. to 3 ft., which it was necessary to remove before the basin could be flooded. All this material was hauled out by two trains of dump cars from the basin to a point below the dam; in all about 80,000 cu. yd. were removed in this way. As most of the water in the stream could be diverted into another channel three miles above the site of the dam, little difficulty was experienced in making the excavation and placing the lower mass of concrete.

The foundation for the dam for the entire length is a gneiss rock found close to the surface, the depth not exceeding 10 ft. at any point. For the most part, however, the rock as first encountered was seamy, although solid, and an extra excavation into the rock was necessary at several points, the maximum being about 6 ft. The rock came out readily in blocks which were bedded into the concrete as soon as actual construction was commenced. No cut-off trench was excavated along the bottom, for in most parts the rock was rough and jagged, and at all points depressed from the downstream side to the upstream side, thus insuring the dam against sliding.

From the same vein of rock that served as foundation for the dam was obtained the stone for the concrete and also the large stone to be bedded into the concrete. One quarry was located at each end of the dam, which facilitated in a great measure the setting-up of the plant. Along the downstream side of the dam for about 600 ft., was built a trestle carrying a track 18 ft. wide and on a curve with a radius of 4,000 ft., approximately following the line of the base of the downstream side of the dam. The trestle was about 23 ft. high, and with the exception of the stringers was built from chestnut sticks cut from nearby woods. A portable saw mill was employed to saw two faces on the sills, caps and ties, the posts and diagonals being scarfed with an adze where they were to be bolted. On the trestle were built two traveling derricks, one to lift the concrete into the dam and the other the plums; these derricks set at such an elevation that the foot of the mast was 10 ft. below the top of the dam. At one end of the trestle was set the mixer and behind it the crusher, the two connected by a track on which ran two cars with compartments for sand and stone. The sand was hauled to the dam for



General Layout of Construction Plant at Trap Falls Reservoir Dam.



SECTION ON A-B

REAR ELEVATION

FLOOR PLAN

SECTION ON E-F

SECTION ON G-H

SECTION ON C-D

SCREEN GUIDES

PLAN, WITH FLOOR REMOVED

ROOF PLAN

Reinforced Concrete Gatehouse, Trap Falls Reservoir.

a distance of a mile and a quarter from a pit and was dumped behind the crusher, where it was loaded into the car to be carried to the mixer with the crushed stone. From the quarry, which was about 300 ft. from the crusher, the stone already broken up into crusher size, was hauled by teams to the crusher, elevated to the bins and loaded into cars through a chute and hauled to the mixer with the sand. The cement was added in the hopper and the water was added in the barrel of the mixer. From the mixer the concrete was run into buckets of 1-yd. capacity on the trucks, which were pushed out on the trestle to the derrick and there lifted into the dam and dumped.

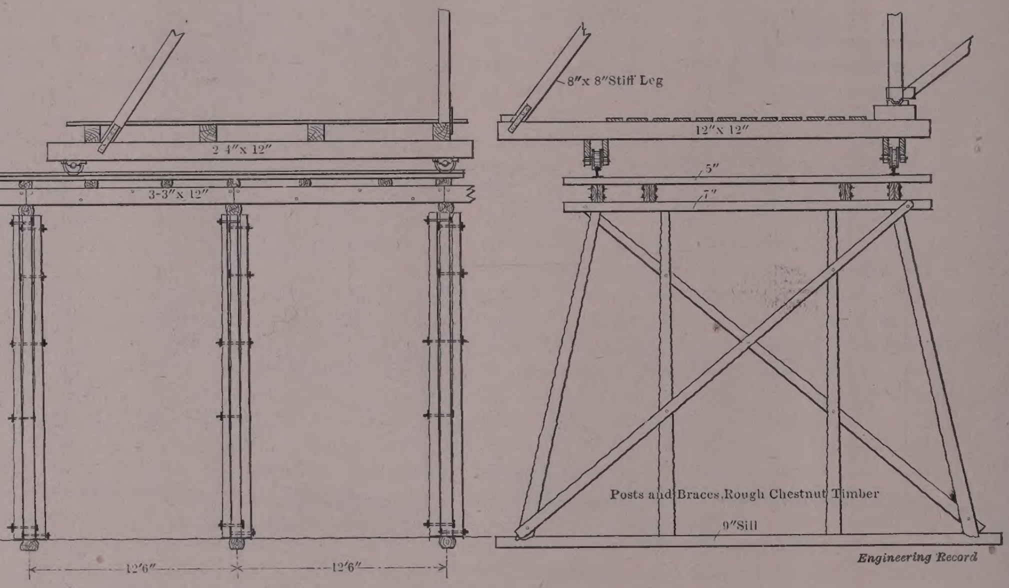
From the other end of the trestle, blocks of stone were let down an incline on flat cars, pushed out on the trestle to the derrick where the stone was picked up and placed in the dam. The gneiss rock, run through the crusher, was not screened, but the run of the crusher was used directly, the finer parts allowing a reduction of one-fourth in the amount of sand necessary. The concrete was mixed in a Ransome mixer of ½-yd. capacity, in the proportion of 1:2½:5 and quite wet, so that when placed it required very little working except careful spading along the forms and joints marking a day's work. The forms for the dam proper were bolted to the concrete with ⅝-in. bolts 14 in. long, thus avoiding all struts and cross braces.

The foundation and all layers of set concrete were coated with a mortar in the proportion of 1:2 before any fresh concrete was placed upon it.

About 20 per cent. of the work was composed of large blocks of stone bedded in the soft concrete and placed not closer than 4 in. apart, the maximum weight of any one stone being about two tons. A stream of water was turned on each block of stone after it was placed on the car at the quarry, so that when landed in its bed of fluid concrete it was clean and dripping wet. These stones were used to within 12 in. of the top. The top, 8 ft. wide, was finished with a granolithic surface and laid off in 4-ft. squares. The gate chamber was built monolithic with the dam, and the floor and roof of the gate house on top of the dam were of reinforced concrete in the proportion of 1:2:4, the reinforcement used being the Ransome system. Atlas Portland cement was used throughout the work.

Work on removing the peat from the basin and excavating for the dam was commenced April 1, 1905, and every thing was finished before Dec. 1. About 11,000 cu. yd. of concrete and heavy plums were placed together. There were no serious injuries to men during the construction work.

Mr. A. B. Hill, M. Am. Soc. C. E., of New Haven, Conn., was the consulting engineer of the work; Mr. S. P. Senior, Assoc. M. Am. Soc. C. E., was the engineer for the Bridgeport Hydraulic Co.; Mr. W. C. Pollitt, C. E., was the resident engineer, and the D. B. Pierce, Jr., Co., of Bridgeport, general contractors, did the work on a percentage basis.



Trestles and Derrick Used at Trap Falls Reservoir.

Shaking Chutes are used to a considerable extent in the stopes of Rand mines, according to a paper by Mr. D. T. Williams before the Transvaal Institute of Mechanical Engineers. It is found that material will slide down a chute having an angle of 40 deg. or more, but when the angle is much less. it is necessary to shake it. This is done by suspending the chute by slings from the roof or from posts fixed in the stope, and giving it a longitudinal motion. Two natives are employed for the purpose, one at the top and one at the bottom. The chutes are made of trough-shaped steel plates and are easily set up and taken down.

Experiments With Copper-Iron Sulphate for Water Purification at Marietta, Ohio.

The water supply of Marietta is drawn from the Ohio River through two suction pipes running out to mid-channel. Each ends in a 15-ft. length of wrought-iron pipe perforated with about 30,000 holes ¼-in. in diameter. The excessive occasional turbidity of the water is indicated by the fact that when the river is in flood the orifices in these inlet pipes stop up rapidly, at times as frequently as every quarter hour, and have to be cleared by back-flushing. The water is raised by centrifugal pumps to the forebay of the purification works, and the great variation in the elevation of the river surface has rendered the operation of the pumping plant rather unsatisfactory at times.

The pumps deliver the raw water to the forebay through a balanced valve controlled by a float. This valve was intended to regulate the height of water in the forebay and the settling basins connected with it, but gave some trouble during the tests of the works. The forebay holds 31,600 gal., and from it the water passes directly to two sedimentation basins, one holding 182,850 gal. and the other 258,750 gal. Both basins are well baffled.

A flume conveys the water from the settling basins to the filters, of which there are eight, each 10x20 ft. in size and housed in a 53x124½-ft. reinforced concrete building. This structure was illustrated in The Engineering Record of April 22, 1905. The eight filters are rated at 4,000,000 gal. per day, including wash-water, and when operating at this rate their yield is a little under 109,000,000 gal. per acre. Each filter has a controller by which its rate of operation can be changed instantly from the operating floor. The filtered water is stored in a clear water reservoir below the filters from which it is pumped to the city.

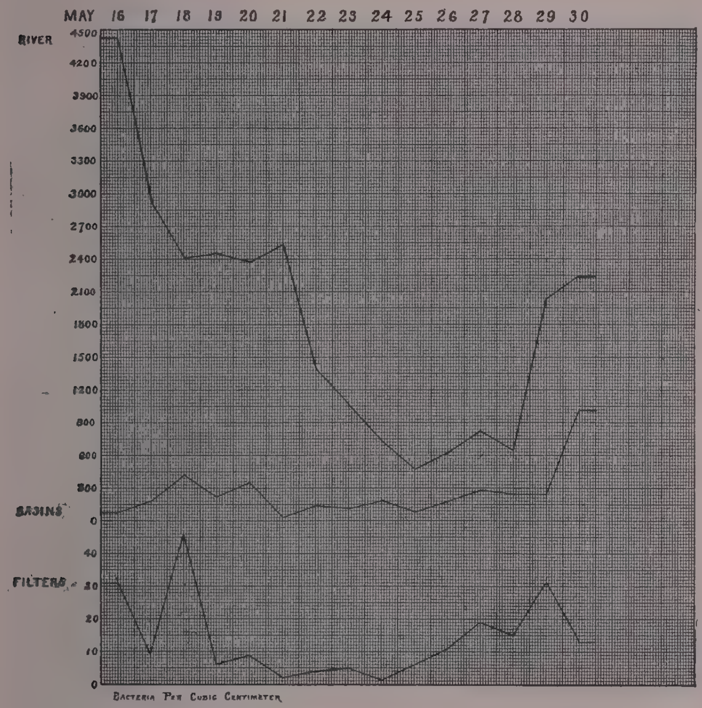
The filters were built for the city by the Norwood Engineering Co., of Florence, Mass., under a guaranty to furnish 4,000,000 gal. of filtered water daily, to remove 98 per cent. of the bacteria in the applied water when the number in the river water averaged 3,500 per cubic centimeter, and to reduce the bacteria in the filtered water to less than 75 per cu. cm. when the river water had less than 3,500 per cu. cm. The works were built to enable either alum or sulphate of iron to be used as a coagulant. The official tests for the Board of Public Service were made by Prof. W. F. Monfort and Mr. C. Arthur Brown, with the aid of Miss Caroline B. Richardson, assistant chemist of the Ohio State Board of Health, and are of special interest on account of the use of copper-iron sulphate as a coagulant while they were in progress. The following information concerning the tests and their results are taken from Mr. Brown's report to the Board of Public Service:

There are four reinforced-concrete chemical tanks, two 9,500-gal. tanks for lime and two 5,000 gal. tanks for the sulphate of iron and copper. The lime was slaked in a special box, using hot water. After cold water was placed in the box, steam was turned on and the water raised to 150° Fahr. The lime was then added, and after it was slaked it was flushed into the storage tanks. With a lime solution carrying 210 grains per gallon, two and sometimes three tanks of lime had to be made up each day. A duplex pump set over the tanks lifts the milk of lime to a head tank under the roof of the chemical room, and an overflow pipe leads from it back to the lime storage tanks. The pump constantly delivers more milk of lime to the head tank than is used, and the superfluous amount returns through the overflow pipe to the storage tanks, agitating their contents and thus assisting in maintaining a homogeneous solution of equal strength. The sulphate of iron and copper dissolves readily, and it was only necessary to place it in a box above the two iron storage tanks and allow a stream of water to pass through it. In making up the iron solution enough sulphate was used to give a chemical strength equal to 1,204 grains of sulphate of iron to the gallon. When the water was at its worst, this strength was doubled. It was only necessary to make one tank of iron solution daily.

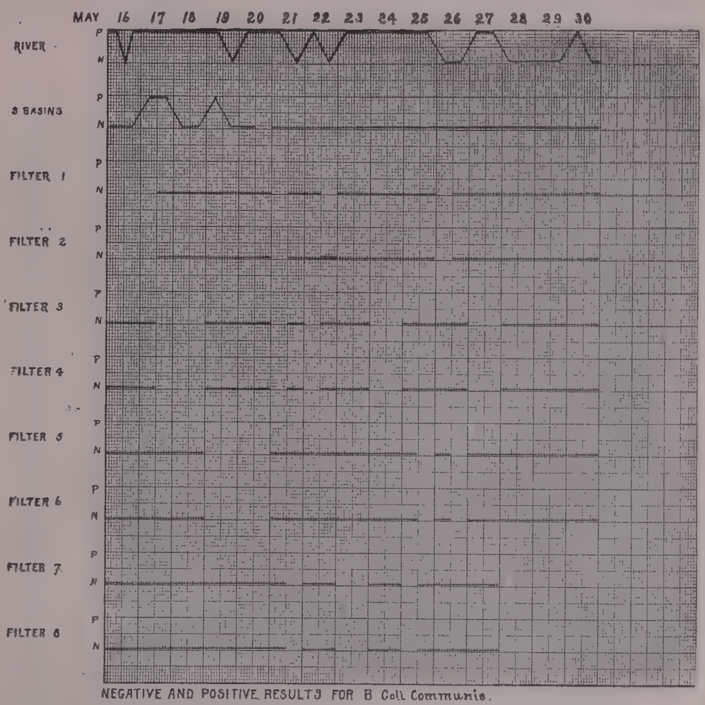
The iron solution passes by gravity from the storage tank through a 2-in. pipe to a constant head and orifice box, placed just above the centrifugal pumps, and is discharged into the suction of the latter. Mr. Brown states that there is no objection to this as the sulphate of iron and copper is specially manufactured for this purpose by the American Steel & Wire Co. and is not corrosive in its action. If the solution is warm the corrosive action is more noticeable.

The lime solution in the head tank in the chemical room is delivered through a pipe into the force main from the pumps at a point just back of the balanced valve. The passage of the water through the balanced valve and the forebay secures sufficient mixing of the chemicals with the water to insure satisfactory coagulation, which takes place almost instantly. Mr. Brown states that plates having rectangular orifices should not be used with lime and iron solutions, as there is a tendency for their corners to build up and consequently reduce the amount of chemical passing through them. If a circular orifice in a thin plate of metal is used, this difficulty does not arise.

When sulphate of copper or sulphate of iron in solution is added in small quantities to a natural water, a partial coagulation occurs, but the reaction is incomplete and all of the iron or copper is not removed from the water, even if it be allowed to pass through a mechanical filter at a slow speed. But if sufficient caustic lime be added to absorb all of the free and a small part of the semi-combined carbonic acid, the chemical reaction takes place almost instantaneously and a perfect coagulation results if enough of the chemicals have been used. Under these conditions the removal of the iron is very complete and the filtered water will usually show less iron than the raw water does. The removal of copper sulphate is equally complete.



General Results of Tests for Numbers of Bacteria.



Results of Tests for B. Coli Communis.

It has been found by experiment that 1 part of copper sulphate dissolved in 100,000 parts of water will destroy the colon and typhoid bacteria in the latter. To treat a public water supply at this rate would cost $4.15 per million gallons for chemicals alone, and as little clarification is effected by this amount of copper sulphate, the process is obviously unsuited for continuous use in connection with fitration or sedimentation. Laboratory experiments had convinced Mr. Brown, however, that the amount of copper could be materially reduced and still enable satisfactory results to be obtained. If sulphate of copper was precipitated with caustic lime and held on a filter, it was found that a natural water without further treatment could be contaminated with cultures of typhoid and colon bacteria, and by passage through the filter containing the precipitated copper a material reduction in the bacteria was effected over and above what could be attributed to the filter unassisted by the copper. Hence it was believed that the time apparently required for the destruction of bacteria by the copper process was not the time required for the copper to remain in contact with the bacteria but that necessary for it to get in contact. It also seemed probable that if a mixture of copper and iron sulphates could be made and used as straight iron sulphate had been, good coagulation, the germicidal effect of copper sulphate, and the complete removal of the iron and copper could be attained. Such a compound sulphate has been prepared by a secret process and was used in the experiments at Anderson, Ind., described by Mr. Brown in a paper before the last convention of the American Water-Works Association. Owing to several unavoidable obstacles in the way of running entirely satisfactory tests at Anderson, the results have been open to some question, and for this reason the Marietta tests are particularly important.

In the Marietta tests the lime used came from Marion, and in addition to containing considerable magnesia was very rocky. Much of it would not slake, but all that was put in the slaking box was charged against the process. The copper-iron sulphate was in the form of crystals of about the same size as the grains of granulated sugar. The 1 per cent. of sulphate of copper was incorporated with the 99 per cent. of sulphate of iron in such a way as to have a perfectly homogeneous and uniform distribution throughout the mass.

The tests began May 16, 1905, and ended May 30, and eleven runs were made in this time, as follows: No. 1, May 16 and 17; No. 2, May 18, 19 and 20; No. 3, May 21 and 22; the remainder were a day each. The results are summarized in the accompanying diagrams. The average results were as follows: Bacteria in river water, 1,913 per cu. cm.; bacteria in settling basins, 258; bacteria in filtered water, 12; turbidity of river water, 305; turbidity of filtered water, 0; color of filtered water, 6; total alkalinity of river water, 20; monocarbonate alkalinity of filtered water, 8; bicarbonate alkalinity of filtered water, 19; total iron in filtered water, 0.03; time between filter washings, 25½ hours; wash-water used, 2.69 per cent.

During run 1, both settling basins were in use and the theoretical time of sedimentation was 3 hr. 47 min. Although the basins are well baffled the actual time required for the passage of water through them is considerably less than the theoretical. During run 2, the larger basin was not used and the time of sedimentation was therefore reduced to 1 hr. 43 min. It will be noticed that the sedimentation results on this run were not so high as on others, although the difference is not so clearly seen in the filtration results. All other runs were made with the complete sedimentation capacity.

The elasticity of the process was shown very clearly by run 5. During this time 3.84 grains of sulphate and 0.47 grain of caustic lime per gallon of water were used, owing to the stupidity of an attendant. Nevertheless the physical condition of the filtered water was perfect and the chemical condition entirely satisfactory.

The high efficiency of sedimentation was not due, Mr. Brown reports, to any superiority in the design of the basins, for other filter plants have basins of practically the same style and relative size, and he ascribes the high results to the process itself. The coagulation caused by sulphate of iron and lime is almost instantaneous, and the flocks are very large and of higher specific gravity than others. Mr. Brown suggests that smaller settling basins may be used with this process than with alum, and the necessity for the preliminary sedimentation of turbid waters is not so great for the absorption of iron sulphate is not noticeable.

The average efficiency of the plant in removing bacteria was 99.33 per cent. for the fifteen days. Out of 228 filter samples taken during the test, 32 proved sterile and 41 contained only two bacteria per cubic centimeter.

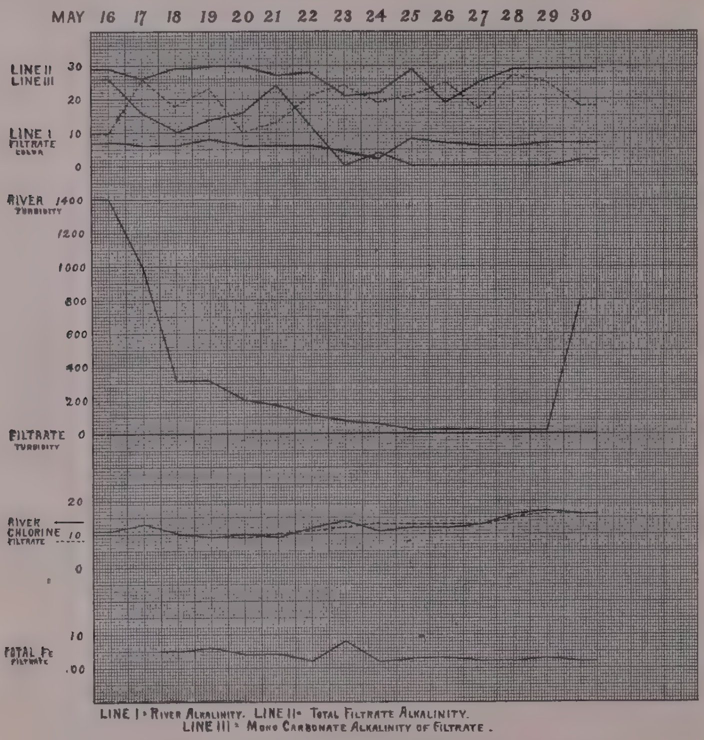
Out of 31 river samples taken, the colon bacillus was found in 20; in an equal number of samples from the effluent of the sedimentation basins only three contained B. coli, and there were none in the samples of filtered water. All suspicious samples were subjected to full routine examinations.

The turbidity was determined by the turbidity rod of the U. S. Geological Survey. The turbidity of the river water was not very high during the tests, but just before they started it reached 12,000 and just after them it rose to 8,000. No difficulty was experienced in handling such waters.

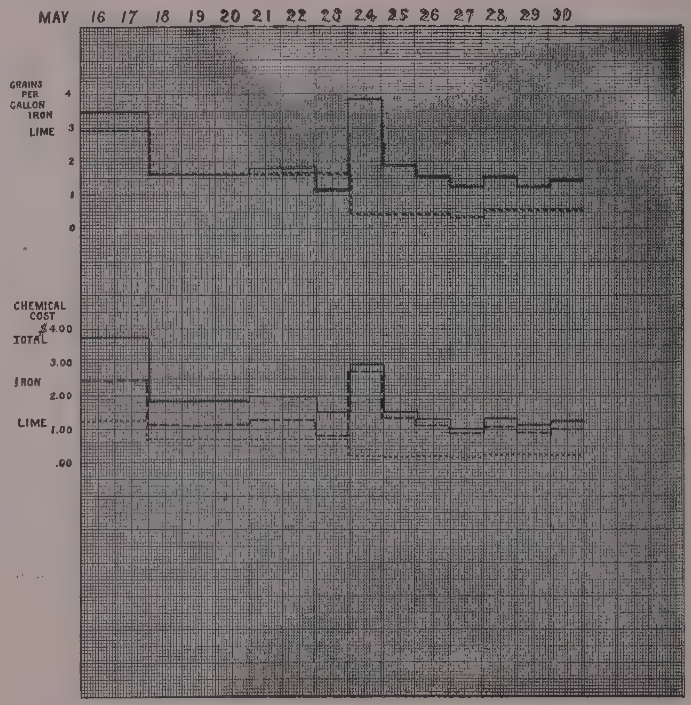
The alkalinity in the river water was determined directly with N/50 sulphuric acid, using methyl orange as an indicator. No trouble was experienced in obtaining sharp end reactions, owing to the care taken in securing a methyl orange suitable for the purpose.

The alkalinity in the filtered water was determined by two readings on one sample of 100 c. c. Phenolphthalein was first added as an indicator and N/50 sulphuric acid run in until the pink color disappeared if one had developed. The reading was then taken and methyl orange added. Enough acid was then added to neutralize the alkalinity. The number of cubic centimeters of acid required for phenolphthalein plus the number required for methyl orange was recorded as the total alkalinity. Twice the number of cubic centimeters required for the phenolphthalein alkalinity was recorded as monocarbonate alkalinity. The total alkalinity minus the monocarbonate alkalinity gave the bicarbonate alkalinity. No caustic alkalinity was found in the filtered water during the test.

The average amount of total iron in the filtered water was only 0.03 part per million. An interesting fact in regard to the use of iron sulphate in this process is that while a ferrous sulphate is added to the water to be purified, it is almost impossible to find a trace of ferrous iron in the water after the lime has been thoroughly mixed with the supply. Samples taken within a few seconds after the lime had been added to the water and examined immediately for ferrous iron failed to reveal any presence of it.



Alkalinity. Turbidity. Color, Chlorine and Iron Tests.



Amount and Cost of Chemicals during Tests.

The maximum amount of iron sulphate was 3.84 grains per gallon of water treated, the minimum was 1.13 grains and the average 1.94 grains. The iron solution was tested by titration with potassium permanganate.

The maximum amount of lime used was 2.91 grains, the minimum 0.38 grain and the average 1.25 grains. The strength of the milk of lime was tested by taking a sample from the head tank, taking 10 c. c. from it with a pipette and adding 500 c. c. of distilled water free from carbonic acid. After thoroughly mixing, phenolphthalein was added and the diluted lime solution thus formed was titrated with N/50 sulphuric acid. The number of cubic centimeters of acid used, multiplied by 3.27, gave the strength in grains per gallon of CaO (caustic lime) available. The strength of the lime solution varied considerably at different times, and in his report on the tests Mr. Brown points out the importance of employing apparatus and methods which will produce a milk of lime of fairly uniform strength.

The chemical cost ranged from $1.04 to $3.72 per million gallons of water filtered, averaging $1.91. This is based on copper-iron sulphate at $11 per ton and caustic lime at $6.

When straight iron sulphate or alum is used as a coagulant there are no apparent germicidal properties manifested by the chemicals, and any removal of bacteria that occurs is probably brought about in a mechanical way and not because of any selective germicidal properties of the chemicals used. With copper sulphate, Mr. Brown asserts, the case is different, and it acts as a germicide to certain species of bacteria when used in very dilute solutions, while other species are not affected. The species that are most easily killed are those of the colon and typhoid groups, which it is most desirable to remove from water supplies. Where no selective action is apparent, as with the chemicals generally employed for coagulation, and only a uniform percentage removal is effected, it is more than likely that some of these undesirable species slip through at times; Mr. Brown suggests that this may account for the fact that no filter plant yet constructed has shown so great a reduction in the case and death rates of typhoid fever as it has in removing percentages of bacteria from the applied water under test. It is accordingly argued that a coagulant that has also a selective germicidal effect deserves careful consideration.

As there has been some criticism of the use of any copper sulphate addition to water intended for domestic purposes, a number of tests were made at Marietta to determine whether any copper remained in the water after filtration, in excess of that in the raw water. For this purpose 200 gal. of river water and the same amount of filtered water were evaporated to dryness. From the river water a residue weighing 750 grams was obtained and from the filtered water one of 71 grams. To these residues were added chemically pure sulphuric acid of 1.84 specific gravity and both were heated until all fumes of sulphuric anhydride ceased to be evolved. Dilute acid was then added to extract the residues and each was subjected to electrolysis. The copper thus obtained was re-electrolyzed from dilute nitric acid. From the 200 gal. of river water was obtained 0.10015 gram of metallic copper and from the filtered water 0.00275 gram. These amounts, when converted into grains per gallon, gave 0.00772 grain for the river water and 0.0002 grain for the filtered water. At the time the 200-gal. sample of filtered water was taken, 1.6 grains of copper-iron sulphate was being used as a coagulant. This is equivalent to 0.0041 grain of metallic copper per gallon of water. Adding this amount to that in the raw river water gave 0.0118 grain of metallic copper to be removed by the filters. On this basis the amount removed was equal to 98.3 per cent. The finding of even such a small amount of metallic copper as 0.0002 grain in the filtered water was something of a surprise to the chemists in charge of the tests, and subsequent experiments were carried through which indicate that it came from various brass and copper fittings through which the water passed. The copper in the raw river water has no germicidal effect because it is present in an insoluble form, probable an oxide.

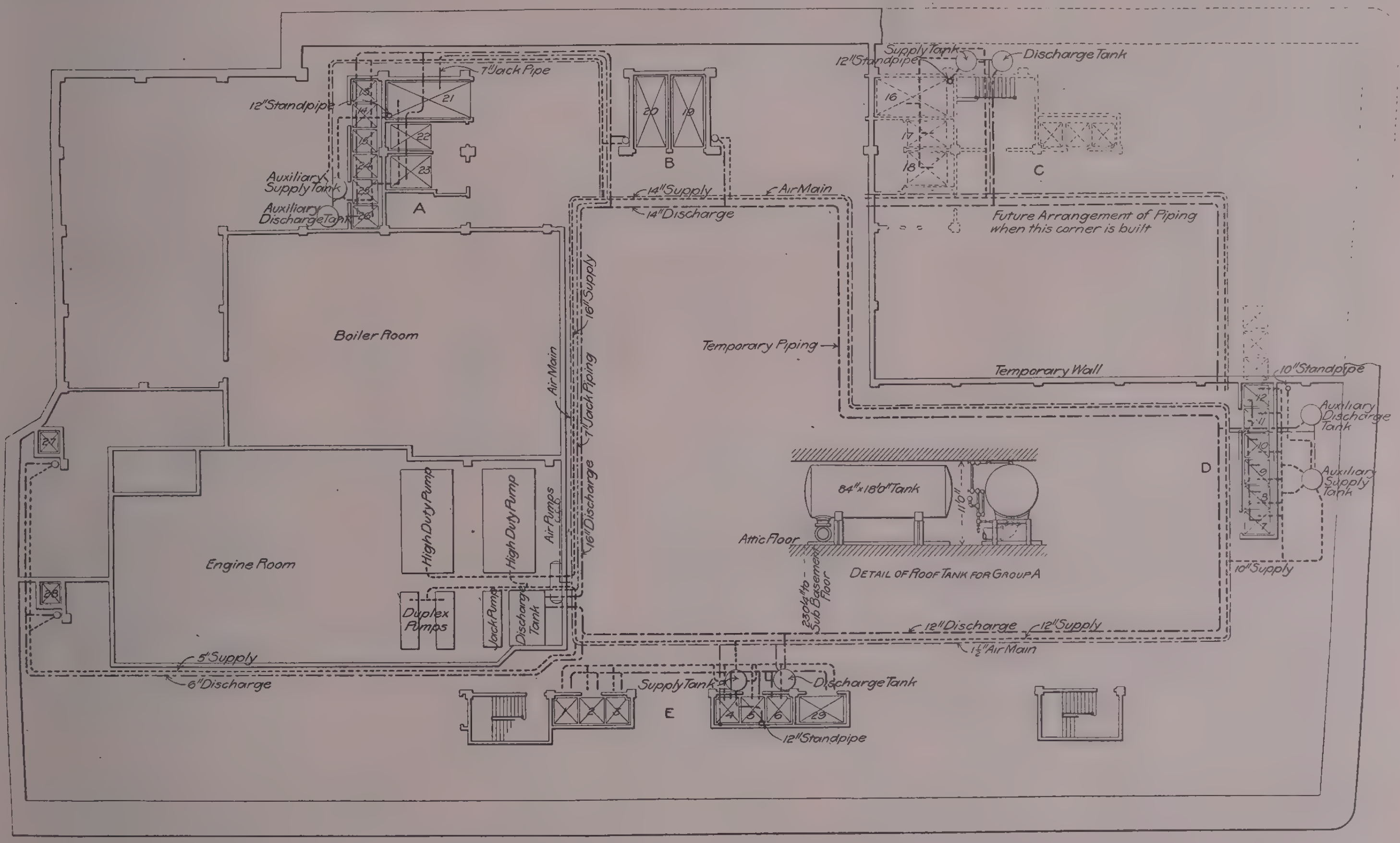
A Ship Yard Gas Power Plant.

The gas power plant at the Dalmuir works of Messrs. Wm. Beardmore & Co., ltd., supplies power for the entire shipbuilding yard, covering 90 acres and having a river frontage of over a mile. According to "Engineering," there are five Duff producers, each capable of gasifying one ton of coal hourly. About 3 tons of steam and 2¾ tons of air are used in the combustion of each ton of coal. The gas is passed through superheaters, mechanical washers, acid towers and cooling towers serving also as scrubbers, before it is delivered to the furnaces in the yard and to the engines. For the latter it is passed through another scrubber and through cleaning fans. There are eight Oechelhauser engines now in use, ranging from 400 to 2,000 h.-p. in rated capacity. Two of them drive air compressors and the remainder are direct-connected to dynamos. Although this is probably the most representative installation of this type of gas engine in Great Britain, it is not so interesting as a 500-h.-p. engine coupled to a sheet rolling mill at the Parkhead Forge, in Glasgow, which turns out weekly from 200 to 300 tons of sheets ranging up to 6 ft. in width and 30 ft. in length.

Mechanical Plant of the New Wanamaker Store, New York.—IV.

Elevator Equipment.—There are 26 elevator equipments of all classes in the new Wanamaker store at present completed, while in the projected section at the Broadway and Eighth St. corner there will be three more. Of these eighteen are passenger elevators, three van elevators, three large freight elevators and two sidewalk elevators, while in the section of the building to be added there will be three large freight machines. The van elevators have been installed to lift delivery wagons and trucks with their horses, thus enabling freight shipments to and from the store to be made directly from the sub-basement or the upper storage and packing floors; these are the highest rise van elevators that have yet been installed.

All elevator equipments in the building are of the plunger hydraulic type, built by the Standard Plunger Elevator Co., with pilot controlled valves and automatic limit stop valves for stopping cars at the ends of their travel. They have a working hydraulic pressure of 160 lb., furnished by two large compound high-duty pumping engines, two compound duplex pumps and a jack pump for use in the lifting of unusually heavy loads upon certain of the freight elevators. The high-duty pumps are three-cylinder fly-wheel-type compound pumping engines, with 17¾ and 22 and 22x12¾x30 in. cylinders, and each has a capacity of 2,250 gal. per min. at 46 r.p.m. against a pressure of 150 lb.; they are guaranteed for a duty of 25 to 27 lb. of steam per horse-power hour. The duplex compound pumps have 16 and 25x15x18 in. cylinders and are rated at 1,100 gal. per min. against a similar pressure. The jack pump is also of the compound duplex type, with 12 and 18½x9x18 in. cylinders, and has a capacity of 400 gal. per min. against a pressure of 250 lb. These are all Laidlaw-Dunn-Gordon brass-fitted outside-center-packed plunger pumps and are controlled by Mason pump governors. They are located in the westerly end of the engine room of the power plant, taking their steam supply from the 12 in. ring steam main, as illustrated in the Feb. 24 issue. Each high-duty pump has a 4-in. steam connection, the compound duplex pumps 3-in. supplies, and the jack pump a 2½ in. connection. All exhaust into a 12-in. line which leads directly to the muffler tank in the boiler room.



Arrangement of Elevator Equipment, Hydraulic Pressure Piping and Pumps in Sub-basement of Wanamaker Store, New York.

The water supply for the pumps is drawn from an 18,000 gal. discharge tank at one corner of the pump room, from which a 24-in. suction header is carried through a trench 5 ft. deep between the water ends of the pumps. The high-duty pumps have 18 in. suction connections to this header, while the compound duplex pumps have 14 in. suction and the jack pump an 8 in. connection. Delivery is made to the pressure supply mains leading to the elevators through a pair of 16 in. pressure headers located in the same trench, one supplying the elevator machines in the north and west side of the building and the other to those on the south side. The two headers are interlinked by a 16-in. cross connection, the high-duty pumps delivering into opposite sides, while the compound duplex pumps, which are to be used principally during periods of light load, deliver together into one side only. All pumps have by-pass connections back to the discharge tank for starting purposes; those for the high-duty pumps are 6 in. and those for the duplex pumps are 4½ in. pipe. The two high-duty pumps have large air chambers on their delivery lines, each a cylindrical steel tank 2 ft. in diameter by 4 ft. long, while the two delivery headers have a cylindrical air chamber, interconnecting them near where they leave the pump room.

The delivery mains to the north and south sides of the building reduce from 16-in. to 12-in. and then 10-in. pipe, and are joined together at the Broadway end of the building so as to make a complete ring circuit of the sub-basement, through which the individual hydraulic machines are supplied. These mains are carried in trenches in the sub-basement floor with checkered cast-iron cover plates. The connections to the elevator machines are simplified by the fact that the various equipments are arranged in practically four groups in the present building and a fifth group for the section to be added at a later time. Near each group there is an auxiliary pressure tank and discharge tank, each 66 in. in diameter by 9 ft. high, by which the pressure in the different parts of the system is equalized and fluctuations avoided. There are three sets of tanks at present installed, one for groups A and B, while groups D and E have each one, group C not yet being installed. At each of these tank supply points there is also a standpipe connection to the roof where tanks are placed 237 ft. above the sub-basement floor. The connections to the auxiliary supply and discharge tanks and to the roof tanks permit any of them to be cut out and the system operated with different combinations of connections. The roof tanks are of different sizes, depending upon the number of machines to be supplied, the largest being over group D, which is 60 in. in diameter by 31 ft. long and is connected through a 10-in. standpipe. The tank over the group A is 84 in. in diameter by 18 ft. long and has a 12-in. standpipe, while those for group E and the projected group C are each 78 in. by 18 ft. and connected through 12-in. standpipes. They are all cylindrical steel plate tanks horizontally arranged and have drip pans under them to prevent possible damage from leakage or sweating.

In both the auxiliary supply and discharge tanks in the basement and in the roof tanks spaces are maintained by compressed air, furnished by three 9½ in. Westinghouse locomotive-type water jacketed steam-driven air compressors in the pump room, which deliver through a ring main of 1½ in. pipe paralleling the pressure mains. By this means air spaces are maintained in each of the auxiliary pressure tanks to the extent of about 40 per cent. their capacity, which is indicated by gauge glasses upon the tanks. The large interconnecting air chamber in the pump room is effective in equalizing the variations of pressure between the two main headers; this air chamber is a horizontal cylindrical steel tank 36 in. in diameter by 10 ft. long, and is connected to each of the 16-in. pressure headers by 12 in. valved connections.

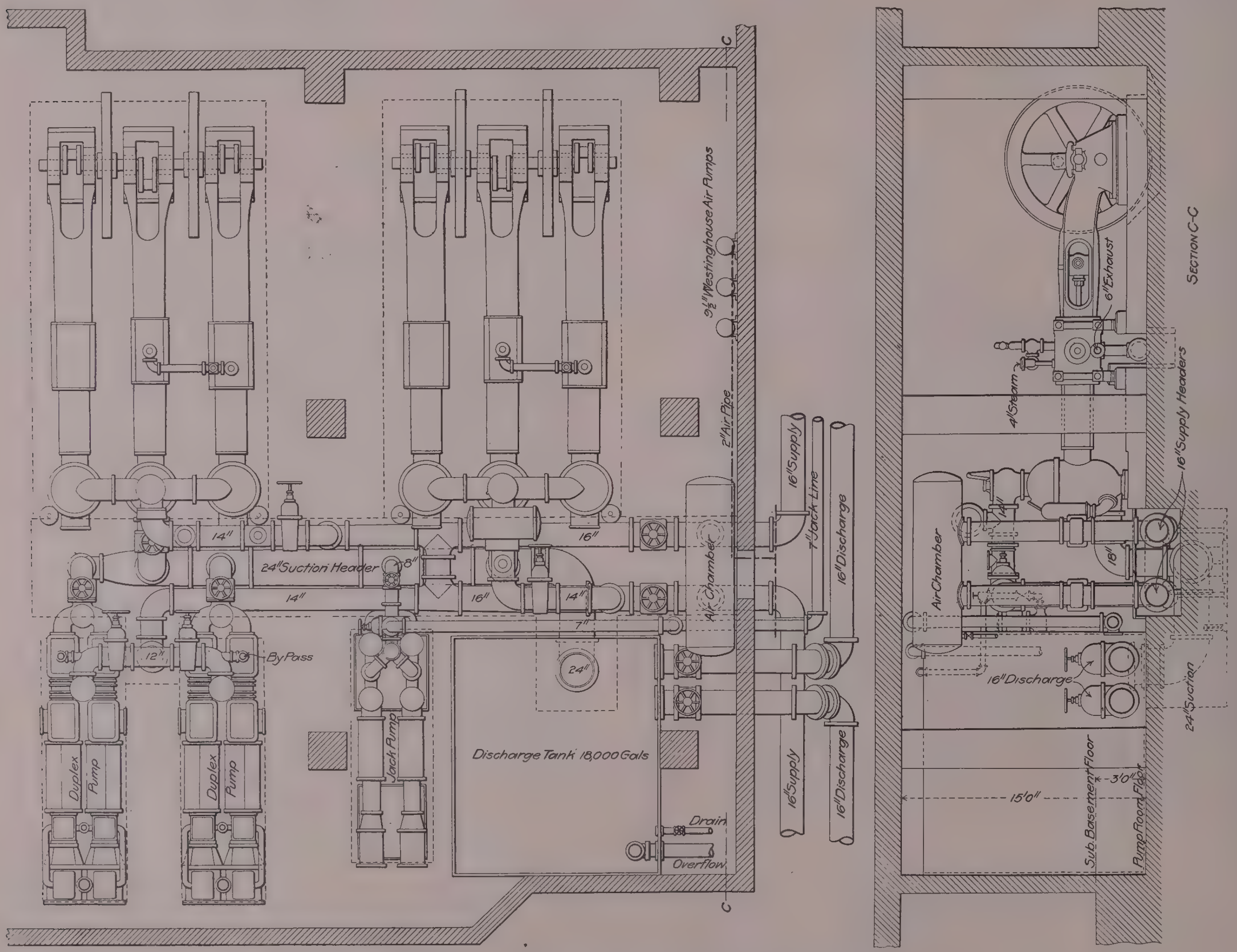
The elevator exhaust system consists similarly of a ring main encircling the sub-basement in the trench with the pressure mains, and the pipe sizes correspond with those of the pressure supply system. The auxiliary discharge tanks are closed vertical steel plate tanks with details like those of the auxiliary pressure tanks, being connected between the elevator valves and the discharge main at each elevator group in order to relieve the discharge line of excessive pressures at times of heavy discharge from a number of machines. They have also connections to the compressed air system and water gauges to enable large air spaces to be maintained in them. The discharge mains are carried back directly to the discharge tank, each opening into it through a 16 in. outlet. This discharge tank has an 8-in. overflow to the sewer, and a drain line, the main 24-in. suction connection to the pressure pumps being taken through a large strainer in the bottom.

The eighteen passenger elevators at present installed have been arranged in three banks of six each, as shown in the accompanying sub-basement plan. Of those on the north side, elevators 1 to 4 inclusive are short travel machines, rising from the basement only to the fourth floor, while Nos. 5 and 6 travel from the basement to the thirteenth floor. Elevator 7, of group D, has a travel from the sub-basement to the tenth floor, while all of the remainder of this group and all six passenger machines in group A travel from the basement to the ninth floor, with the exception of Nos. 25 and 26 which travel to the roof. The rise from the sub-basement to the tenth floor is 170 ft.; basement to ninth floor, 131 ft. 9 in.; basement to thirteenth floor, 200 ft.; basement to roof, 231 ft. 5 in. All passenger elevators have 5½x6-ft. cars and are designed for speeds of 400 ft. per min. with loads of 1,200 lb. Their maximum capacities are 2,500 lb., at which loadings they will operate at speeds of 150 ft. per min.

At present there are three van lifts and three ordinary freight elevators. One of the van lifts, No. 21, is a machine running from the sub-basement to the thirteenth floor, for raising vans and trucks directly to any of the upper shipping and packing floors, thus obviating all handling of freight at the street entrances. The other van lifts, Nos. 19 and 20, rise from the sub-basement to the delivery wagon concourse at the street level on Eighth St., the purpose of these machines being to handle trucks and vans between the street and shipping room in the sub-basement only, a travel of 25½ ft. The two sidewalk elevators are similarly of short rises, one having a travel down to the boiler room floor for the handling of ashes and supplies to the boiler room, while the other travels to the sub-basement at the rear of the engine room. The three remaining freight elevators, Nos. 22, 23 and 29, travel from the sub-basement to the thirteenth floor, with the exception of No. 22, which rises to the fourteenth floor.

The three van lifts are of unusual size, the two short-travel lifts having cars 8¾x18½ ft. in size and the high rise lift a 9¾x20 ft. car, which will thus accommodate the average van or truck and its horses with ease. The other three freight elevators are of smaller sizes, No. 22 having a 6½x10 ft. car, No. 23 a 8½x10 ft. car, and No. 29 a 8x12 ft. car. The latter three have 10½-in. plungers and with loadings up to 6,000 lb. operate at speeds of 200 ft. per min. The van lifts have exceptionally large plunger mechanisms, the cylinders being 20 in. in diameter and the plungers, 17¾ in. These cars have, under normal operating conditions, capacities of 8,000 lb., at which loadings their speeds are 150 ft. per min., but with the jack pump pressure, have capacities of 15,000 lb. at 75 ft. per min. They are heavily counterweighted, the high-rise van lift having eight 1¼ in. counterweight cables, running over two sets of 60-in. sheaves, and the remaining freight elevators six 1¼-in. cables with 76-in. sheaves.

The valves for both passenger and freight equipments are of the standard pilot-controlled type, with limit stop valves for automatic stopping of cars at top and bottom. The control valves of the freight equipments have 6-in. pressure supply and discharge valves, while the equivalent connections of the passage elevators



Arrangement of Pumps and Piping Connections in Pump Room.

are 5 in. lines. The passenger machines have 6½ in. plungers which operate in 10 in. cylinders, and all have six ⅞ in. counterweight cables running over two 48-in. sheaves. All of the elevators are equipped with the flash system of car annunciator supplied by the Elevator Supply & Repair Co., New York.

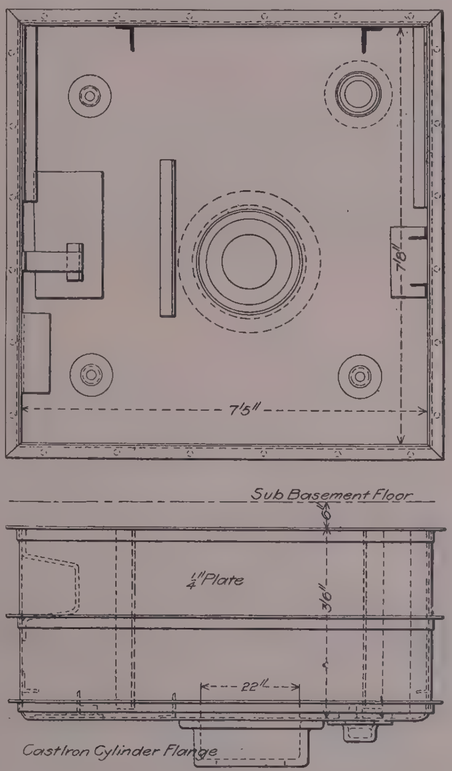
For the lifting of very heavy weights, such as safes and heavy pieces of machinery, there is installed an extra high pressure line connecting with certain of the freight elevators and supplied by the jack pump in the pump room. The jack pump is in design similar to the duplex pumps, except that it has a cylinder ratio of 2 to 1 instead of 5 to 3, for a delivery pressure of 250 lb. This system is used only on special occasions and when so used the regular control valve for the elevator is cut out of service and the jack pressure turned directly into the valve independent of the control system from the car. This jack system is connected only to freight elevators 21, 22 and 23, in group A. For use in this service these elevators have locking fastenings at each floor for locating the car rigidly at any floor for loading or unloading. The jack pump delivers through a 7-in. pressure line which is carried in the trenches across the building to the elevator control valves at this point, with 6-in. branches to each.

As the sub-basement floor is 25 ft. below street level and a large number of springs were encountered in the excavation, heavy steel plate pans were sunk in the control valve pits. The cylinder casting is tightly fitted into the bottom of the pans, which are bedded in the concrete floor. An accompanying drawing illustrates the pan for a passenger elevator in group D. It is of ¼-in. steel plate, stiffened with angles and has a cast-iron cylinder flange riveted to the bottom through which the top of the plunger cylinder protrudes and is bolted tight with gasket. Around the outside edges there were riveted three rows of 3-in. angles which project outward and thus formed lips to assist in making a tight joint with the concrete floor. In one corner of each pan there is a cast-iron sump from which possible cylinder leakage may be pumped.

The pit pans for the van elevators were full size and presented many difficulties of fitting and installation. The clearances were very small and it was necessary to avoid building column footings at the sides and corners, which was accomplished by beveling the sides at the bottom. For van lifts 19 and 20, a single pan was used which necessitated special construction to avoid columns and still permit being set in place after riveting up. This pan is 19½x21 ft. by 6 ft. 8 in. deep, and, on account of limited space for installing was built in two halves, which were riveted together and calked at the joint after being located in the pit. Both the front and back sides of this pan are beveled off for nearly 5 ft. at the bottom edges to afford the necessary clearance of foundations. The cylinder flanges used here are of extra size with 23½ in. openings to provide for the 20-in. cylinders.

Van lifts 19 and 20 are fitted with cars of special design owing to the service from the sub-basement up to the delivery wagon concourse only. For this reason an undertrussed car framework is used which does not limit in any way the possibilities of loading. The car consists of an 8½x19 ft. framework of 12-in. channels with a 15-in. channel 11½ ft. long, arranged vertically at either side carrying the guide shoes. Two 15-in. I-beams are fitted across, between the frame channels at the middle to provide for the plunger fastenings, which consist of a platen of ½-in. steel plate between the I-beams, stiffened by 9-in. cross I-beams with bracket fillers to the upper flanges of the large 15-in. beams. The weight of the platform is distributed through the side posts by four 4x4x½-in. angles on either side, two of which act as braces to the corners of the platform and the other two, struts from the inside of the posts to the cylinder fastening platen. Each car has a double wooden platform carried on 10-in. cross channels spaced 2 ft. apart. Protection at the sides is afforded to employees by guards of 2½-in. diamond-mesh wire netting which rise to a height of 5 ft.

The high-rise van-lift car is of extra heavy construction, weighing 14,720 lb. It has a platform framing of 12-in. channels with a post on either side formed of a 15-in. channel, to carry the guide shoes. The side posts project above the car platform with braces of 4½x½-in. bars reaching from the top to each corner and to points midway between on the side of the frame for stiffening. The posts are tied together at the top by two 15-in. channels in which is located an equalizing pulley mechanism for the eight counterweight cables. This car has a locking mechanism to permit rigidly locating a car at any floor level; it consists of two heavy dogs sliding in guides beneath the car platform which may be extended into latch openings provided in the steel work in the sides of the shaft. These are extended by means of a special level mechanism, operated through a handle which is a counterpart of the main control lever of the car.



Details of Elevator Pit Pans

Sprinkler System.—An extensive system of automatic sprinklers has been installed in the building, the most notable feature of which is the use of concealed piping, only the sprinkler heads appearing through the ceiling finish. The system is operated on the wet system plan, except in locations where the piping is susceptible to freezing, where the dry pipe system is in use. The sprinkler heads have been distributed about 10 ft. between centers in either direction, except in certain locations where the rows are 8 ft. apart; the majority of the heads, however, cover areas of 100 sq. ft. The present installation has over 8,000 heads for which 220,000 ft. of pipe was required. The system has been designed to provide for the 1,500 additional heads which will be necessary in the section of the building to be built later at the Broadway and Eighth St. corner.

Water for the sprinklers is supplied by four 12,000-gal. steel pressure tanks and four 20,000-gal. gravity tanks above the roof of the building, and four hose connections to the system at the street level for the city fire engines. The 12,000-gal. tanks are kept under an air pressure of 75 lb., the air occupying approximately one-third of their capacity. The air is furnished by a steam-driven air compressor in the engine room. The sprinkler piping on each floor is supplied through risers, connecting with an 8-in. trunk main in the sub-basement which connects directly with all of the sprinkler tanks, there being valves in the connections to each section of every floor, together with the drain connections, for cutting out and draining off any portion of the system when necessary. In the basement and all of the main retail floors up to the ninth the distribution piping is concealed above ceiling, only the sprinkler heads themselves projecting downward a few inches through the finished ceiling. In the fur cold-storage vaults, in the show windows and in the delivery wagon concourse on Eighth St., the dry pipe system is used, the pipes being normally filled with compressed air and the water held back by automatic dry-pipe valves; this eliminates the possibility of freezing and bursting of these pipes, but will permit the water to flow at any time after the air pressure is released by the opening of any of the sprinkler heads.

In addition to the sprinkler system proper, there is a separate fire service consisting of four standpipes, near the stairways, with hose on reels connected at every floor. These standpipes receive their supply from four large house tanks on the roof and also have street connections for fire engines. This entire installation has been made by the General Fire Extinguisher Co., New York, the Grinnell automatic sprinkler head having been used throughout.

Refrigerating Plant.—The refrigerating plant consists of two Carbondale absorption refrigerating machines of 50-tons nominal capacity, each capable of cooling 125-gal. of brine per minute from 10° to 0° F., and is arranged to run with exhaust steam from the power plant of the building. Each machine is complete with its own cooler for the brine which is circulated throughout the building. The condensation from the exhaust steam coils of the ice machine generators is returned to the feed water heaters by gravity and connections with the Webster system permit of vacuum return when the buildings are being heated. The water from the machines runs into a waste water tank, where it is pumped to supply all the various purposes of both of the buildings.

There are two 6½x8-in. triplex double-acting brine pumps driven through Morse silent chains by Crocker-Wheeler motors and each has a Cutler-Hammer universal starting box arranged to furnish different speeds by field control. The brine pumps take their suction from the brine tank and deliver through the coolers, with a discharge line leading up to the kitchen on the ninth floor and fur room on the thirteenth floor of the new building, and also a separate line running to the restaurant to be installed in the old building. All of the brine mains are insulated with "Nonpareil" cork brine pipe covering. The kitchen on the ninth floor is fitted to supply a large restaurant, the following equipment of refrigerators being cooled by the brine circulation: For cheese, a 5x3½x5-ft. size; oysters, 5x3½x7 ft.; orders, 7 ft. 2 in. x 3½x5 ft.; meat, 20x10x8 ft.; stores, 8x6x8 ft.; pastry, 6x3½x7 ft.; cold meats, 6x3½x7 ft.; serving meats, 8x3½x8 ft.; vegetables, 7x6x8 ft.; ice cream, 16 ft. 8 in. x 2 ft. 9 in. x 3 ft. 2 in., and 10 ft. 2 in. x 3 ft. 3 in. x 3½ ft.; ice storage, 10x3⅔x2⅔ ft.; garbage, 10x9½x8 ft.; fish orders, 5x3½x5½ ft.; caraffe freezer, 12x4x8 ft.

The fur storage room starts on the eleventh floor and extends up to the thirteenth in one large room 86 ft. wide, 60 ft. long, and 28 ft. high. The coil bunker is located on the fourteenth floor occupying a space of 38x17x10 ft., from which a circulating fan located on the thirteenth floor delivers the air to the fur room beneath through a system of distribution ducts. These ducts are arranged so that they will not interfere with an elaborate system of pipe racks and galleries for the hanging of the furs, all of this iron work being built inside of the fur room after it was finished. There are two anterooms on the eleventh floor and also a show anteroom about 17 x8x12½ ft. with a large plate glass show window; the only entrance to the fur room is through the anterooms on the eleventh floor.

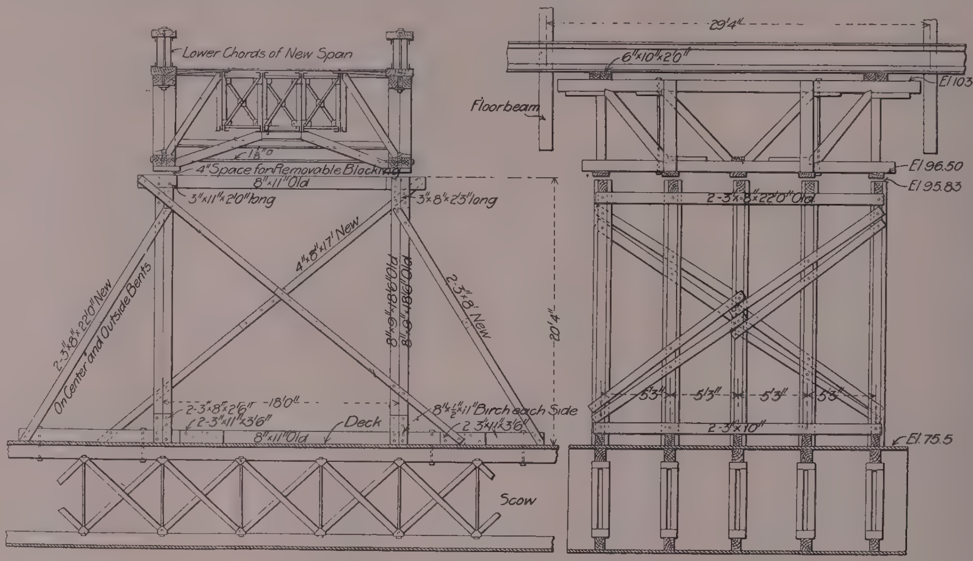
In addition to the two electrically-driven brine pumps and electrically-driven ammonia pumps, there are also two 5x6-in. triplex drinking-water pumps for circulating cold drinking water through seven lines of risers with faucets, four risers in the new and three in the old building. These pumps are driven by Crocker-Wheeler electric motors with Morse chain drive, the same as the other pumps, and the drinking water is cooled in a galvanized iron tank, 4½x6½x6 ft. in size, in the basement and fitted with brine circulation coils. The brine lines are also used to cool the soda water for the fountains.

The special features of this plant are the arrangement of the brine circulation, the electric pumping equipment, the use of exhaust steam in the ice machine and the extensive fur vault of 141,000 cu. ft. which in itself is as large as many cold storage houses. The entire equipment was installed by the Carbondale Machine Co., Carbondale, Pa.

TECHNICAL EDUCATION is being criticised in Germany as in the United States on the ground that there are not enough technical positions for the graduates. The proposition to establish an industrial school in Mannheim called forth some vigorous protests which U. S. Consul Harris in that city has reported to the Department of Commerce and Labor. It was pointed out that the attendance at the ten German polytechnic institutes increased from 5,432 in 1890-91 to 15,866 in 1904-5. On the other hand, there has been a decrease of theological students in Prussia from 2,713 in 1887-88 to 1,005 in 1903-4. The Prussian medical students likewise fell off from 5,168 in 1887 to 3,020 in 1903-4. While there has been such a great diminution in the attendance in the divinity and medical departments of the universities the numbers in the scientific technical departments has increased from 1,100 in 1901-2 to 3,015 in 1903-4. The attendance at the trade schools has similarly grown. As a result there is said to be a great surplus of technically educated men in Germany, with a consequent very low rate of compensation. According to statistics compiled from inquiries sent to 20,000 technical men, one-fourth had salaries of $430 per year or less and only 19 per cent. received over $714. However, all salaries are low in Germany.

The Erection of the Miramichi Bridge.

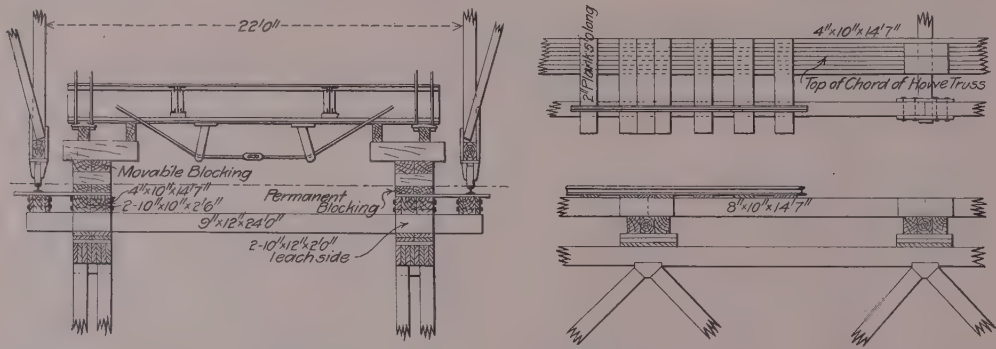
The northwest and southwest branches of the Miramichi River join about one mile above Newcastle, New Bunswick. The head of ocean navigation is about one mile above the junction where each branch is crossed by a single-track bridge of the Intercolonial railway, each bridge consisting of six 204-ft. spans supported on stone piers with caisson foundations. The superstructure had double intersection pin-connected Whipple trusses about 30 ft. deep and 17 ft. apart, built with Phœnix columns and erected by Clark Reeves & Co., in 1870 to 1874. They had suspended floor beams reinforced, about 1888 with truss rods, and each span weighed about 448,000 lb.



Details of Tower Bents on Scows.

The replacement of the old bridge was undertaken in 1902 by the Dominion Bridge Co., Mr. Phelps Johnson, manager, and Mr. H. D. Bush, resident engineer. The old substructure was retained and new spans weighing about 540,000 lb. each and designed in accordance with the Intercolonial specifications of 1901, were erected on them. Their connections were all riveted and they were proportioned for uniform live loads per lin. ft. of 5,900 lb. for the trusses, 6,750 lb. for the floor beams, 9,100 lb. for the main stringers and 10,600 for the stringers and floor beam connections.

The bridge across the northwest channel was erected in 1902 as was described in The Engineering Record of March 14, 1903. In the following year the bridge across the southwest channel was erected in a similar manner, but several important changes were made in the details and methods which will be here described, reference being had to the previous article for many of the details common to both erections. The northwest spans were erected in pairs side by side on pile falsework driven near the shore parallel with the old bridge. As soon as practicable after each span was riveted complete a pair of scows with falsework towers built on their decks were floated under it, a small amount of water ballast was removed by hand pumps and with a rising tide the span was lifted clear of the falsework, towed to position between the piers and deposited

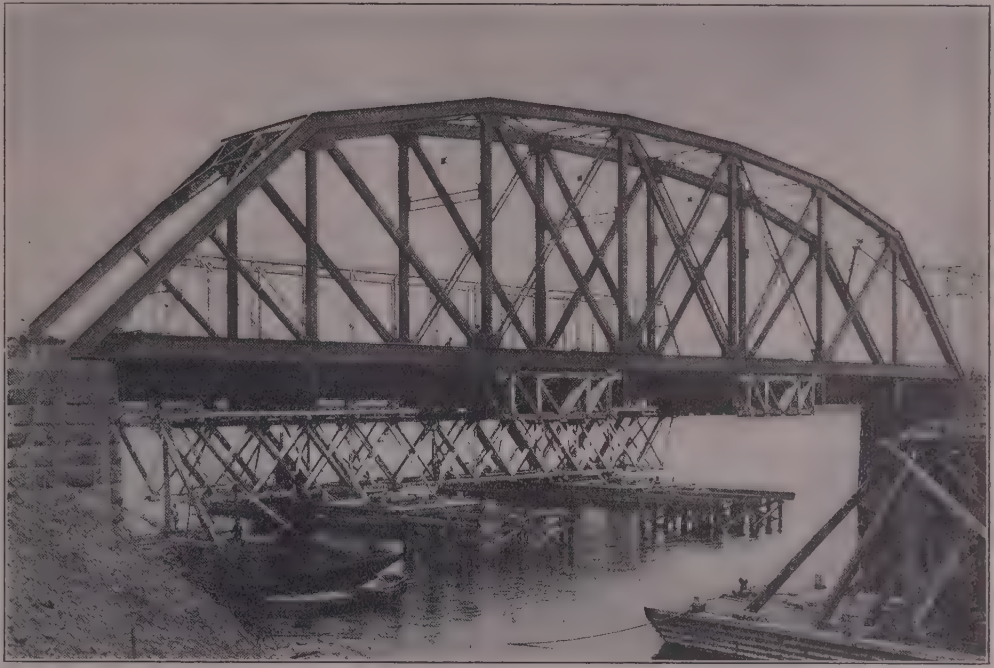


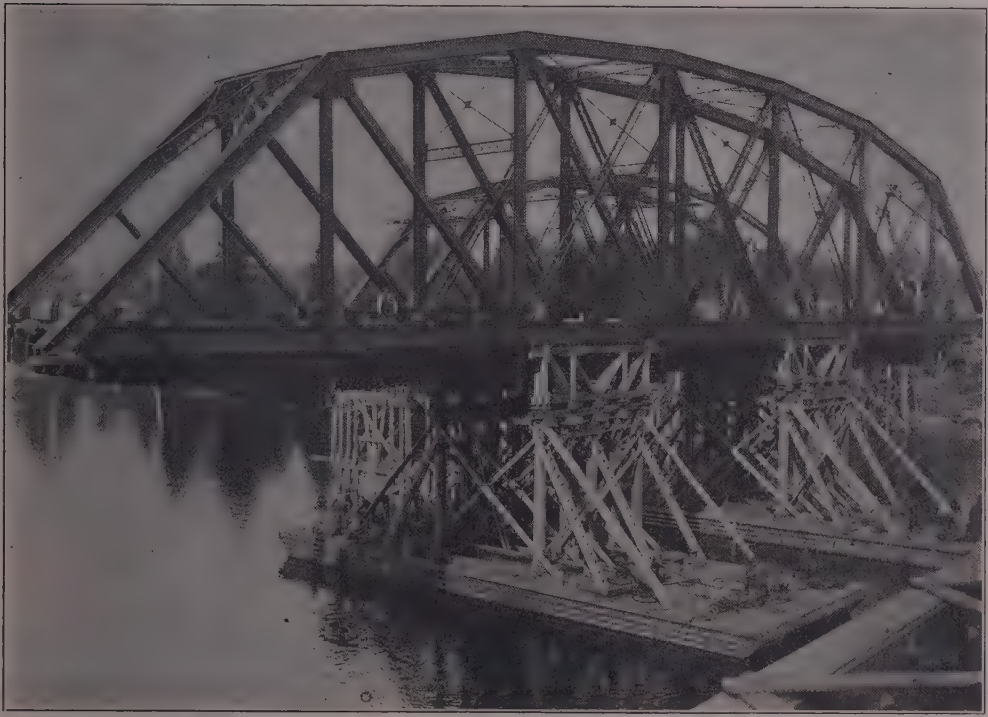
Details of Modifications in Tops of Tower Bents for Removing Old Spans.

View of Pair of Northwest Spans on Pile Falsework.

on them by scuttling the scows generally just at high tide, but occasionally while the tide was still rising, necessitating quick action. The water was admitted into the scows through two 6-in. valves. The double falsework permitted one span to be riveted up while the other was being erected and so expedited their construction. The old spans were handled on a pair of combination Howe trusses neatly as long as the old spans, braced together and seated across the decks of another pair of water ballasted scows and placed under the trusses of the old spans in their planes. The weight of the old span was partly lifted by the rising tide. The water ballast, when all was ready, was quickly thrown out by centrifugal steam pumps and as the old span was pulled out the new span immediately took its place. The details of the scows, towers, falsework trusses, and of the careful calculations made for the floating and lifting of the spans are fully described and illustrated in the previous article.

The grade of the spans in the southwest bridge is about 4 ft. higher than that of the spans in the northwest bridge, and on this account it was necessary to provide some special method of extending the falsework towers in order to utilize the timber bents which had been stored there since the erection of the former spans. The towers were originally made with five vertical transverse bents with their caps wedged to bearing against the track stringers. The sills of the bents were seated on longitudinal timbers on the deck of the scow which extended the bearing and distributed the load, but as the width of the bearing in the stringers was only 9 ft., additional security for the top-heavy structure was obtained by six inclined posts on each scow.


One of the Spans in Place.


Scows with Falsework Towers Supporting Span, Ready for Towing into Position.

For the erection of the southwest channel bridge the vertical posts of the tower bents were arranged in pairs, five of which were placed in the plane of each bridge truss and braced together to make a single bent. These bents were braced together to make an 18x21-ft. tower as indicated in the accompanying illustrations. The space between the top of the tower and the stiff lower chord of the new span was occupied by two wooden trusses suspended from the latter and provided with bearing blocks on their upper chords at each end, and lower chords at each panel point so as to support the span at two points and distribute the load equally over each of the five double posts in each bent. The five tower bents were in the planes of the five longitudinal stiffening trusses in the scows and were seated on sills about 40 ft. long with inclined braces at each and, this providing a very stable support. The trusses in the scows were designed to distribute the load.

When high tide occurred at a time of day when the railway company would permit the track to be broken for 4 or 5 hours the new span was lifted and floated out near its proposed location and the old one was partly lifted by the tide as above described. From the time the steam pumps were started for the final lifting of the old span it was generally less than an hour before the new span was settled into position.

The total time from breaking to re-connecting track averaged about four hours. The lifting of the new span was done gradually. The water ballast in the scows under the new spans was removed by hand diaphragm pumps at inappreciable expense as at this time the men would otherwise have been idle. The average tide was 2 to 3 ft. with occasionally 4 ft. at full of the moon. The plans therefore always contemplated the use of some water ballast and some pumping.

The old spans from the northwest bridge were unloaded from the scows on pile trestle platforms in shallow water parallel with the shore, moved ashore on trucks and there dismembered. This system would have been an expensive one for the railroad company on the southwest bridge because it required a shore front of over 300 ft. which the company did not possess and would have had to pay a heavy rental for. Mr. Bush therefore devised a simpler and more economical plan which confined the operations entirely to the river and the railway right of way and enabled the work to be done more quickly and cheaply than before. The old spans were removed with the same arrangement of Howe trusses and scows as before, but the blocking on top of the Howe trusses to receive the old spans was modified as indicated in the accompanying details. Transverse timbers about 14 ft. apart in sets of three were placed on the top chords of the Howe truss so as to overhang them about 4 ft. at each end and carry outside rails for the track of an ordinary gantry traveler which cleared the old span and ran over it from end to end. The Howe trusses and bracing carrying each old span were deposited on a few pile bents driven close to shore and arranged to leave clearance for the scows. As soon as each old span was taken out the scows and load were towed or pulled to these bents. The scows were then lowered by admitting water and removed. The old span was then parallel to the bridge and on a structure not affected by rising and falling tides. With the traveler the old span was then entirely dismembered and the different pieces, commencing at the river end, were taken ashore on trucks moving on the original track of the span which had not been disturbed. The floor system and this track were removed last of all, working from the river to the shore end and thus completing the work without the necessity of building any special track or providing yard room on shore. The work was done under the general direction of the Engineering Department of the Intercolonial Co., Mr. W. B. Mackenzie, chief engineer.

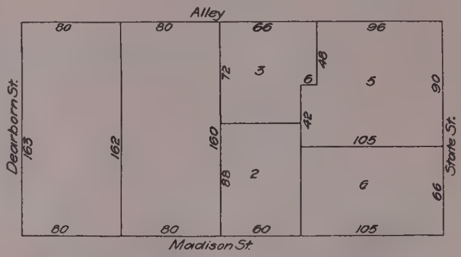
Difficult Shoring Work for Buildings in Chicago.

A 192x360-ft. department store building, with three floors below and 14 stories above the street grade is being erected in the downtown retail business district of Chicago for the Boston Store. The site of the new building covers a full half block, facing on three streets with a 16-ft. alley at the rear. It was occupied, with the exception of a 99x105-ft. office building, 14 stories high, facing on two streets at one corner, by 5 to 7-story brick and stone buildings. The new building is to be a steel-cage, fireproof structure built on circular concrete footings carried down to bed rock, 110 ft. below the street grade. The three basements and the first seven stories of the new building are to be built at once. The footings and sub-structure of the building are designed, however, to carry the full 14 stories, and the top 7 stories will be erected as soon as necessary after the basements and the first seven stories have been completed over the entire site.

The new building is being erected in five sections in order to meet business conditions. The business of the store at the time construction of the new building began occupied the lower six floors of the 14-story building and a 6-story building on each side of the latter as indicated by the areas Nos. 2, 5 and 6 on the accompanying plan. One of these 6-story buildings extended from the 14-story one to the alley way; the other abutted against the 14-story building on the other street front of the latter and has a frontage of 80 ft. on that street. Adjoining this building, on the area No. 1 in the plan, was an old 6-story theater and office building. Between this theater building and the third street, at the other end of the site from the 14-story structure, are several other old office buildings of various heights occupying area No. 4. The first section of the new building has been erected on the site of the old theater building. It is 80x162 ft. in plan and has the three basements and the seven stories the remainder of the block is to have.

At the time construction was commenced it was imperative, owing to the congested condition of business in the store, that before any of the structures occupied by the latter could be removed a space should be available in the new building at least equivalent to the space afforded by the building to be wrecked. Furthermore, the possession of the office buildings on area No. 4, between the old theater building and the third street, could not be obtained at that time. The old theater building was therefore wrecked first. It had a party wall with the old 6-story building adjoining it which was occupied by part of the store. This wall was also removed when the theater building was wrecked and sheeting built over the exposed side of the store building, the side of the latter being carried on shoring. The superstructure of the first section of the new building necessarily had to be erected and made ready for occupancy before the portion of the store building adjoining it on area No. 2 could be wrecked. Its footings were, for that reason, completed as soon as possible after the old theater building on its site had been removed. The steel columns of the framework were immediately set up on these footings, the steel work of the superstructure rapidly erected and the superstructure completed. The excavation for the basements were then made, the steel-work of the sub-structure of the building erected and the basement floors laid.

The schedule of the work thus followed, although complicated under ordinary conditions, was rendered particularly difficult by the treacherous character of the foundations and by the type of construction of the old buildings in the vicinity. The foundations are typical of those in a greater part of the downtown business district of Chicago. The top 10 to 12 ft. is filling material, placed in raising the grade of the city. Below this is a 3 or 4-ft. layer of water-bearing loam, under which is blue clay. The clay extends to bedrock, 110 ft. below the street grade at the site, and increases in density until it becomes hardpan before rock is reached. The old buildings adjoining the site of this section are on spread, or on floating foundations, and usually with their exterior and partition walls built separately. The clay on which these buildings are erected makes a good foundation when confined, but toward the surface carries enough water to cause it to move readily under pressure, if not completely restricted. The floor of the lower sub-basement of the new building is 45 ft. below the street grade. A heavily reinforced-concrete retaining wall will be built on all four sides of the portion of the building below that grade to prevent the lateral motion of the clay surrounding the basements. The steel-work and the floors of the sub-structure have been designed to balance the thrusts on these walls. The lowest floor has also been designed to overcome any upward thrusts that may come against it due to the pressure of adjacent buildings on the semi-plastic stratum of clay beneath it.



Plan Showing Order of Work by Sections.

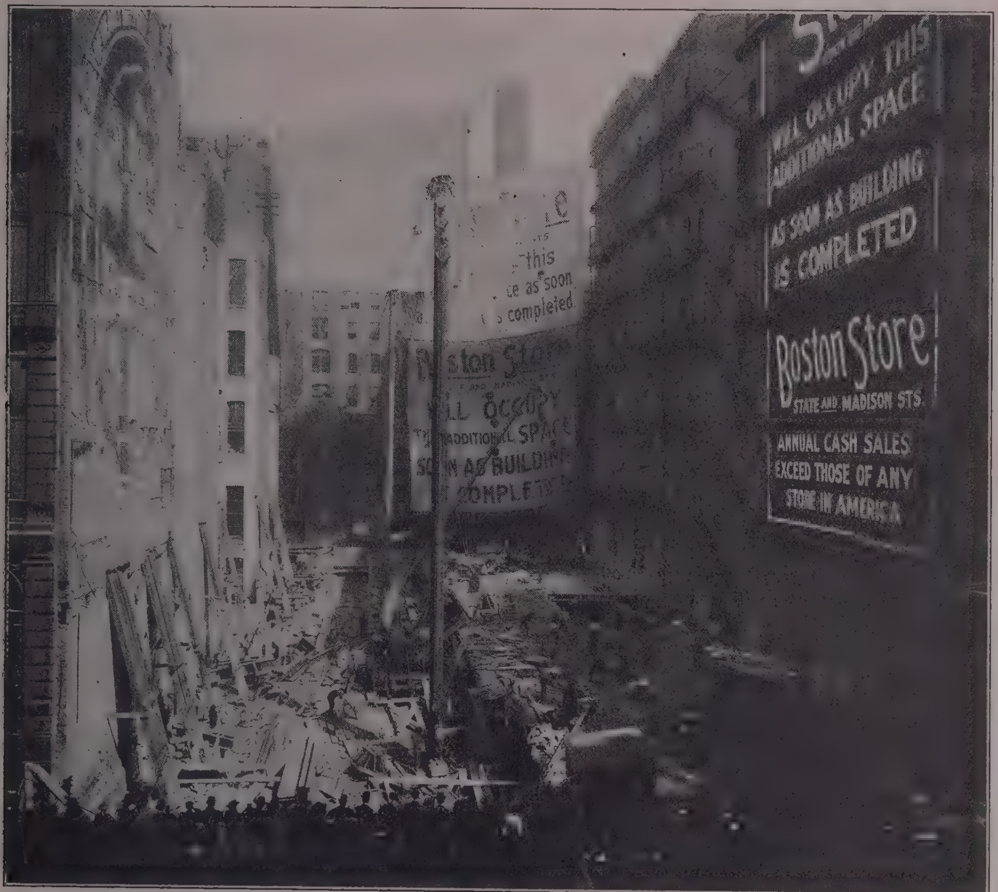
These adverse foundation conditions, which the new building has been designed to meet, had to be provided for as fully as possible during construction. In erecting the section of the building which is now nearly finished, a trench, 5 ft. 6 in. wide in the clear, was dug around all four sides of the site to the lower sub-basement floor grade, 45 ft. below the street. This work was carried on after caissons for the circular concrete footings of the building had been sunk, and before the excavation for the basements had been carried below the top of the clay, 10 to 12 ft. below the street grade. The trench along one side of the site of the section had to be excavated immediately under the side walls of the old 5 to 8-story office buildings on that side; along the other side it was placed under the site of the old party wall between the old theater building and the old 6-story store building. The side of the latter and the walls of the old office buildings on the other side of the site, occupying area No. 4, were raised from their original footings and placed on shoring while the old theater building was being wrecked.

This shoring consisted of 15-in. I-beams placed transversely under the walls as required and carried at each end by a steel jack-screw on a hollow 8x8-in. drum, the drums standing on a cribbing of timbers built up from the clay. The two cribs carrying each beam were placed far enough apart so the trench could be excavated between the two rows of cribs on each side of the trench site. Owing to the extremely heavy loads brought on the soft clay by the shoring and the buildings in the immediate vicinity, the trenches had to be dug with exceeding care and to be very heavily sheeted and braced. The excavation was first carried down the full width of the trench for a depth of 3 ft. It was then lined on each side with 3x5-in. tongue and grooved lagging, in 3-ft. lengths, placed vertically. A continuous row of 6x8-in. waling pieces was placed inside of each row of lagging, reducing the available width of the trench to 4 ft. The center line of a row of the caissons for the concrete footings of the new building coincided with the longitudinal center line of each of the four trenches. The waling pieces in one side of the trench were braced against those in the other side with 5-ton jack-screws spaced according to the span of the walings between the caissons. When the top 3 ft. of the trench had thus been sheeted the next 3 ft. was excavated and sheeted in the same manner until the bottom of the trench had been reached, over 2,300 jack-screws being required for the braces in the trenches.

Starting Excavation for First Sub-basement after Completing Superstructure.

The concrete retaining walls around the site of the entire new building will be reinforced with 20-in. I-beams, placed vertically on 2.5-ft. centers.

When the trenches had reached the required depth, a layer of concrete about 18-in. thick was put in the bottom of them, and the lower end of the I-beams placed in this concrete before it had set. In order to afford proper bracing for the sub-structure steel-work during construction, and to provide a support for the ends within the new building site of the I-beams carrying the old building walls on each side of this section of the new basement, a temporary wall formed of 20-in. I-beams, placed vertically on 2.5-ft. centers, also had to be erected in the trench along each side of the basement. The I-beams in the trenches were all diagonally braced against each other and placed against the lagging and bracing of the trenches. The forms for the concrete retaining walls at the front and rear of the site were built up in the trench between the lagging. The concrete was carried up in layers about 1.5 ft. thick, the forms being built up about that much at a time. The jack-screws were removed as the concrete work reached them, and were replaced by blocks wedged between the wall and the trench walings. As the excavation was made the vertical beams in the trenches were braced against the steel-work of the basement floors.



Buildings in Vicinity of First Section Supported on Shoring.

Meanwhile, the concrete footings on which the steel columns of the framework of the new building stand were finished. The columns were then erected on them and well sway-braced against heavy waling pieces attached to the lagging with which the caissons in which the footings had been built were lined. About the time the super-structure of the building was completed and occupied the excavation for the basement was commenced. As this excavation was carried down, the columns of the building were braced against each other and against the I-beams in the trenches until the first basement floor level was reached. The steel-work of that floor was then assembled, and the concrete floors laid as fast as the steel-work was in place, the temporary braces being kept in place until the concrete had set. The excavation was then continued to the first, and finally to the second sub-basement floor levels in the same manner. The clay was hauled to a chute in wheelbarrows and removed through the tunnels of the Chicago Subway in a manner similar to that described in The Engineering Record for March 10, until the lowest level had been reached. A connection from the tunnel was then extended into the building and the excavated material dumped directly into the tunnel cars. The service afforded by the tunnels greatly facilitated the methods of construction followed. In fact, the order of construction carried out could not have been obtained if the usual method of hauling out the basement excavation with teams had been required.

Before the excavation for the basement had been started, the cribbing under the ends within the new building site of the I-beams carrying the walls of the adjoining old buildings was removed. One end of each of these I-beams was then carried on the top of the vertical 20-in. I-beams in the trenches along the side. The other ends of the beams rested on the same jack-screws which had carried them from the start. In a few places, brackets were temporarily riveted on the steel columns of the new building which were on the line of the old building walls, at the first floor level and the old walls are carried by I-beams on these brackets until the old buildings are wrecked.

Shoring work on each side of the old theater building, prior to the wrecking of the latter, was commenced July 5, last. The old building was wrecked July 11, and the caissons for the footings of the new building started the following day. The erection of steel-work on the concrete footings began August 4; the seven stories above the street grade were completed and occupied Dec. 10. The excavation for the two sub-basements was commenced about Jan. 1, followed by the placing of the basement floors, and the mechanical plant for this section of the building is now nearly all installed in the second sub-basement. The second section of the new building to be erected will occupy the site, 60x88 ft. in plan, on which the 6-story store building next to the first section stood. This building has just been wrecked. The other sections will be erected in the order of the numbers as shown on the accompanying cut of the plan of the site. The entire block is to be completed ready for business by November 1, next, according to contract.

The precautions that had been taken to prevent the lateral movement of the clay under the adjacent buildings were entirely successful. That no lateral displacement occurred is shown by the fact that after the columns of the steel-work of the building had been placed and were carrying the superstructure with the temporary braces in the 45 ft. of height between the grade of the lowest floor and that of the floor at the street grade, all of the steel-work of the three basement floors fit without cutting. The excavation for the basements extends 45 ft. below the street grade, while that for some of the masonry settings for the mechanical plant is carried down 7 ft. below the lowest basement floor. When these excavations were made and the pressure relieved on the semi-plastic clay a horizontal movement of the latter, due to the pressure of the adjacent buildings on it, appears to have taken place under the trenches around the site of the first section of the new building. This movement caused considerable settlement in the adjoining buildings. By carefully shoring these buildings from their old footings on drums and jack-screws so that the screws could be extended as the clay settled, the walls of all the affected buildings have been in place with practically no interruption to business in those structures which have been fully shored.

Just across the 16-ft. alley way along the rear of the site of the new building is a building wall 360 ft. long. This wall is the side of 5 to 8-story brick buildings on spread footings. It was lowered by the lateral displacement, under the trenches for the section of the new building, of the clay on which its footings stand. Included in this wall, but built separate from it, are two square brick smoke stacks, one 110 and the other 150 ft. high. These stacks are about 100 ft. apart and close to the excavation that has been made. An 8-in. settlement of the footing of the higher stack has occurred since the jacks were put in, but the stack has been maintained at its former level. The other stack had also settled, and the wall had gone down varying amounts depending on the proximity to the excavations.

The higher stack is 12x12 ft. at the base and is estimated to weigh 800 tons. The weight of the stack was gradually transferred from the footings to eighty 50-ton screws. It is kept at its old level by extending the jacks as the clay slips from beneath it. The other stack and the wall have also been shored with jacks set on the footings and in all cases have been held at their original levels. Over 1,000 jacks are under the wall and the two stacks. Levels are taken daily on the structure at different points and the jacks will be taken out and the wall underpinned down to the old footings. This shoring work was made additionally difficult by the location of a crowded engine room for the buildings in the vicinity of the two stacks and by the occupancy of all the buildings by tenants who could not be disturbed.

The shoring required in the construction of the new building and that under the old buildings in the vicinity is being done by the L. P. Friestedt Co., building, raising and moving engineers, of Chicago. Messrs. John Griffith & Son were the general contractors for the excavation of basements of the first section of the new building. Messrs. Holabird & Roche, of Chicago, are the architects for the new building.

The Electric Equipment of the New York, New Haven & Hartford R. R.

The problem of equipping the New York end of the New York, New Haven & Hartford R. R. with electric locomotives is somewhat complicated by the fact that the locomotives must operate on direct-current over the New York Central part of the New Haven system, and on alternating-current on its own part of the line. In an interesting paper read last week before the New York Railroad Club, Mr. B. G. Lamme said that this complication is not nearly as great as would appear at first thought, for the type of locomotive chosen is one which adapts itself well to both classes of service. There is necessarily some duplication of parts on the locomotive, such as the collecting devices, certain details of the controllers, wiring, etc., but on the other hand, it is surprising how many parts are common to both classes of service.

The main power house is at Riverside, about three miles from Stamford. The generators in this power house are to be driven by steam turbines. The machines have single-phase ratings of 3,750 kw, or about 5,500 kw on three-phase, the armature winding being such that three-phase current can be obtained from the same machine. The generators have two poles and at 1,500 r.p.m. give 3,000 alternations per minute or 25 cycles per second. Such a generator would have been considered an impossibility only a short time ago, and the design of these machines was one of the difficult problems in this undertaking. After a suitable construction was worked out, the manufacture of these machines appears to be comparatively easy. The machines have an ample margin, both electrically and mechanically, and they are particularly well adapted for handling inductive loads. As an illustration of unusual conditions met with in the design, Mr. Lamme mentioned that a single complete armature coil weighs about 600 lb. As these machines are to feed directly into the trolley system, they are wound for the normal trolley tension of 11,000 volts, and in consequence one terminal of each machine is always grounded when in service, as in usual practice with direct-current railway generators.

As the railroad company contemplates operating certain existing direct-current systems from this power house it was decided to add an additional leg to the armature winding, so that three-phase currents could be obtained for feeding into rotary converter stations for furnishing direct-current for some lines which, at the present time, cannot be conveniently changed to straight alternating-current. The New Haven company also has other fields for three-phase power which it proposes to take care of as soon as it is feasible to do so.

The steam turbines for driving these generators are of the well known Westinghouse-Parsons type. On account of the large output and high speed an unusually good performance is indicated. The engines are designed for the single-phase rating of the generators, as it is anticipated that the heavy service and the load peaks will be due to the railway load.

As 11,000 volts will be applied directly to an overhead trolley and as the trolley system will span from four to six tracks, it is evident that a very substantial overhead construction must be used. The construction of this overhead system is one of the most interesting features in this whole electrical system. The trolley system is to be suspended from steel bridges which span from four to six tracks normally, and even a greater number at special points. These bridges are placed at intervals of about 300 ft. and at points about two miles apart heavier structures called anchor bridges are placed.

The steel cables which support the trolley wire proper are supported by massive insulators on the bridges. Two cables are used for each wire and form a double catenary suspension carrying the trolley wire by means of triangular supports. The double system of suspension gives increased stiffness to the trolley construction. The triangular supports are placed about 10 ft. apart. The steel cables have a total sag of about 6 ft., while the trolley wire itself is maintained in a practically horizontal position.

At points corresponding to the anchor bridges; that is, about two miles apart, each trolley wire is broken by section insulators and is connected to the other trolley wires and to two feeder wires through automatic circuit breakers. Otherwise each trolley wire, with its cables and supports, is insulated from the adjacent wires. In this way each wire is sectioned and a short circuit on any one section can cut it out without putting the neighboring wires out of service. The two feeder wires just mentioned are carried the whole length of the alternating system, and by means of these and the arrangement of automatic switches, any entire section of four or more trolleys could be cut out of service and the sections beyond can be kept in service.

The trolley wire has a nominal height of 22 ft. above the track. This height will vary a few inches up or down with wide variations in temperature. The pantagraph type of trolley used on the locomotives has an effective range of about 8½ ft. and therefore a very considerable variation in the height of trolley is permissible.

The overhead system is designed to be amply safe under abnormal conditions, such as high wind or heavy coating of ice. The stresses in the supporting cables with a load of ice ½ in. thick on the cables, hangers, etc., will be about one-sixth of the ultimate. The stresses in the structure due to wind have been figured on a basis of 16⅔ lb. per square foot, projected surface for the cables and 25 lb. per square foot normal surface for flat surfaces. Allowance is made for double these pressures in summer when there are higher wind velocities, but under this condition the cables will be of much smaller diameter in the absence of ice.

As 11,000 volts is used on the trolley system, no transforming stations are necessary on the part which is now to be installed. The high voltage trolley system will extend about 19 miles in one direction from the power house and about 3 miles in the opposite direction to Stamford. This system could be extended in the latter direction approximately 20 miles further, if desired, without transforming sub-stations. Therefore about 40 miles of the trolley system can be supplied directly from the main power house. With a locomotive load representing 4,000 kw. about 19 miles from the power house and a corresponding load 15 miles away, or 4 miles from the power house, the drop at the end of the line will be about 13 per cent. This drop is on the basis of feeding into the load from one direction only. If there were a transforming sub-station about 40 miles away from the power house, feeding into the same trolley system, then the drop at a point 20 miles away would not be 13 per cent., but would be considerably less as power would be supplied from both directions. It is apparent therefore, Mr. Lamme pointed out, that with sub-stations along the line feeding into a common trolley system, such sub-stations could be possibly 60 miles apart. For example, if a transforming sub-station were placed in New Haven about 40 miles away from the power house, the drop at the midway point between the sub-station and power house would be equivalent to a load on the present system at 10 to 15 miles from the power house. However, the above distances between sub-stations are so great that it might prove inadvisable to feed more than one or two sub-stations from a given plant, two or more power plants being installed on a very long system.

The electric locomotive is the part of the electrical equipment which will doubtless excite the most interest, principally because it is a new-comer in an old field. From the standpoint of the designer the generating system and overhead construction may present just as interesting features, but to the layman in the electrical field there is but little with which to make comparison; but when it comes to the locomotive the general problem is much better understood. The frame, trucks and cab of this locomotive were built by the Baldwin Locomotive Works on designs developed after many conferences between the New Haven company, the Baldwin Locomotive Works and the Westinghouse Electric & Manufacturing Co. The design adopted was partially determined by the fact that the motor equipment must be suitable for use on both alternating and direct-current. This to a certain extent controlled the number and size of the motors and thus affected the construction of the trucks and other parts. The results have turned out so well, however, that there is every reason to believe that this type of locomotive will be used in future even where alternating-current alone is used.

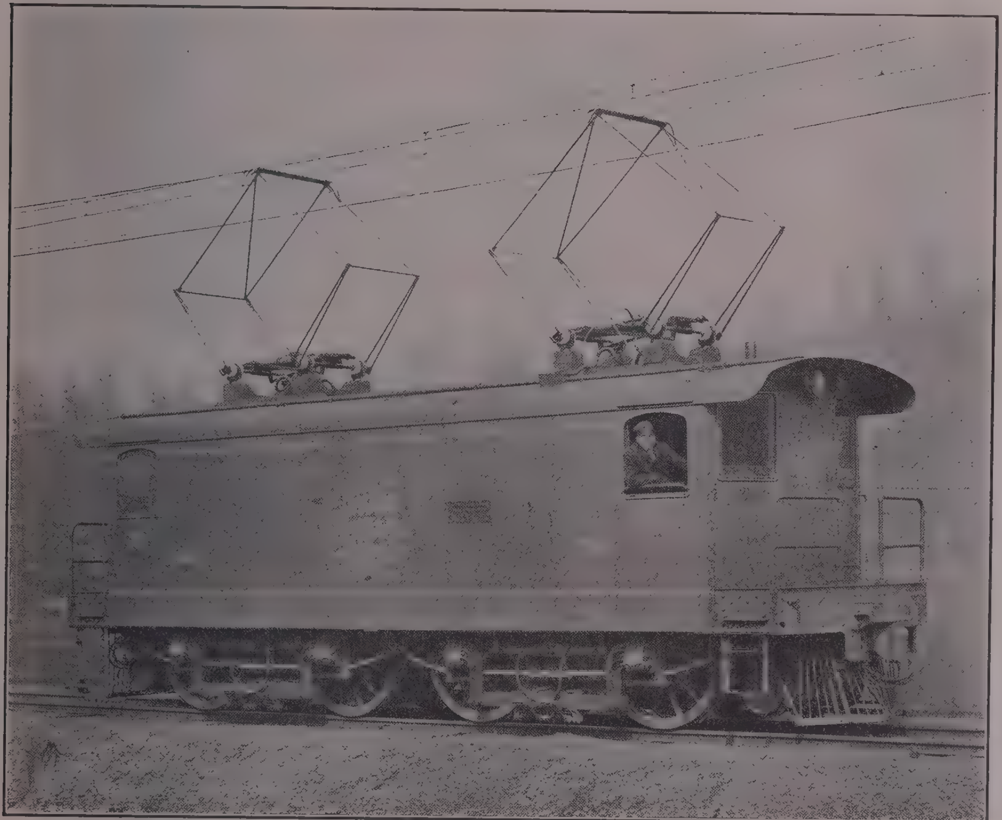
The mechanical construction of the locomotive presents many novel and interesting features which deserve special consideration. The running gear consists of two trucks, each mounted on four 62-in. driving wheels. The length of wheel base is 8 ft. The side frames are of forged steel and to them are bolted and riveted the pressed steel bolster carrying the center plate. The weight on the journal boxes is carried by semi-elliptic springs with auxiliary coiled springs under the ends of the equalizer bars, to assist in restoring equilibrium. The bolsters are 30 in. wide at the center plate and are widened, where bolted to the side frames, to nearly double this amount, thus giving a very strong construction without excessive weight. The center plate which transmits the tractive effort to the frame is 18 in. in diameter and will be lubricated to permit a perfectly free motion in curving. The truck centers are 14 ft. 6 in. apart.

Owing to the fact that the entire space between the wheels is occupied by the motors it was impossible to transmit the drawbar pull through the center line of the locomotive in the usual way. Instead of this, strong plate girders heavily cross braced are carried outside of the wheels and the entire strain of the drawbar is carried to these through strong box girders having top and bottom plates 42 in. wide. Directly underneath the girder at each end is a Westinghouse friction draft gear to which the drawbar is attached. The entire design lends itself to a very strong construction without great weight. The cab is built up of sheet steel on a framework of Z bars. The apparatus inside the cab is carried on a framework of structural steel which is built into the cab and firmly anchored to floor and ceiling. Over each motor is a large trap door which permits easy access to motor bearings, brushes, etc.

The motors are four in number, each of 250 h.-p. nominal capacity but with a continuous capacity of over 200 h.-p. each or over 800 h.-p. total. The motors are of the gearless type and are wound for a normal full load speed of about 225 r.p.m. They are connected permanently in pairs and require about 450 volts at the terminals on alternating current and 550 to 600 volts on direct-current.

The frame and field of each motor are split horizontally and can be removed in halves in order to give access to the inside of the field or to the armature. The armature is not placed directly on a shaft but is built up on a quill through which the car axle passes with about ⅝ in. clearance all around. On this quill, at each end, are placed bearings which carry the field frame.

At each end of the quill is a flange from which project seven round pins, parallel to the shaft, into corresponding pockets in the hub of the wheel. Around each pin is placed a coiled spring wound with the turns progressively eccentric. These springs are contained between two steel bushings, the smaller of which slips over the pin, and the larger fits in the pocket in the wheel. These springs are amply strong to carry the entire weight of the motor but are normally required to transmit only the torque of the motor and to keep the motor axis parallel to the axle. They allow a total vertical movement of about ¾ in. The end play of the motor, instead of coming directly on the wheels, is taken by strong coiled springs inside of the driving pins which press against covers in the outer ends of the spring pockets in the wheels. The torque on the motor frame is taken by heavy parallel rods which anchor the frame to the truck above and below the axle. These rods permit vertical or side motion of the motor but prevent excessive bumping strains from coming on the motor driving springs. The entire weight of the motor is normally carried on springs supported from a steel frame surrounding the motor and resting on the journal boxes.



Electric Locomotive for use on the New York, New Haven & Hartford R. R.

The motors are internally of the same general type which the Westinghouse Co. has been building for some time for interurban service, but, owing to their relatively low speed, the maximum commutator speed is very low, being less than 3,000 ft. per minute when the locomotive is making 60 miles per hour. This may be compared with 5,000 to 7,000 ft. commutator speeds which are frequently attained in both direct and alternating-current, high speed service with fairly large motors.

One interesting feature in these motors is the method of cooling. As a blower is used in the locomotive for cooling the lower transformers, it was decided to extend this method of cooling to the motors also. In the floor of the cab is an air conduit of considerable size from which air is piped to each motor. This method of cooling improves the continuous capacity of the motors, and another very great advantage lies in the fact that the motors can be kept very clean in this manner.

On the direct-current part of the line, current is taken from the third-rail system, except in the case of some short sections at cross-overs fed from an overhead trolley on direct-current. The motors are controlled in the usual series-parallel method in combination with resistance.

On alternating-current the motors are not operated in series parallel, but are connected permanently in a given manner and the supply voltage is varied. This gives an equivalent of the series parallel, except that the number of efficient operating steps is much greater. On alternating-current operation no resistance is used in regular running, but a slight amount is used in passing from one working step to the next, this being in the nature of a preventive device to diminish the short-circuiting effect when passing from one transformer tap to another. There are six operative voltages, or running points, on the alternating-current, corresponding to six taps on the lowering transformer, while there are a small number of intermediate steps, which are used only in passing from one working point to another. Experience has shown that the number of steps on alternating current required to give a smooth acceleration is considerably smaller than required on direct current. In consequence the controller is so arranged that on alternating-current about half as many steps are used as on direct-current. The tests have shown that the acceleration on both alternating and direct-current is very smooth.

There is one feature in the direct-current control which is not generally found at the present time on direct-current equipments, namely, shunting the field for higher speeds. On the series position on direct-current the motors have an efficient running point. It is usual railway practice to pass from the series to multiple position by introduction of resistance, there being no intermediate efficient running speed. On the New Haven equipments, however, the type of motor used is one which permits an almost idefinite shunting of the field without affecting the commutation or operation otherwise, and advantage is taken of this to obtain several higher speeds by shunting the fields before passing into multiple. In this way several efficient running points are obtained between the series and multiple. The tests have shown that these motors will operate in a perfectly satisfactory manner on direct-current with their fields shunted down to much less than half their normal strength.

When operated on direct-current, as stated before, the current is fed directly to the motors. On alternating-current, however, step down transformers must be used, as the alternating-current trolley voltage is 11,000. The step-down transformers are two in number, one on each side of the cab, in order to balance the weight in the cab. It must be borne in mind that these transformers are the heaviest single pieces in the cab and there would be considerable difficulty in placing a single transformer to advantage. A further reason for two transformers is that an injury to one could not entirely disable the locomotive. The transformers are connected in parallel across the high voltage, but on the low-voltage side each transformer feeds one pair of motors, through a separate control unit. This means that the controller when operated on alternating-current consists of two normally independent units.

The main controllers are of the well known Westinghouse electro-pneumatic unit switch type. The design, however, differs somewhat from the straight direct-current type, due to the fact that switches, blow-outs, etc., must operate on both alternating and direct current, as many parts of the controller are common to both. It may be mentioned also that the reversing switches are of the unit switch type.

The main controllers are operated from master controllers at each end of the cab. The controller system is arranged for multiple unit operation so that two or more locomotives may be coupled to the same load.

In addition to the controlling and transforming apparatus there are auxiliary parts, such as two air compressors driven by motors which can be operated on either alternating or direct-current; two blowers driven by similar motors, for furnishing air to the transformer and motors, and to the direct-current rheostat. It may be mentioned that the air which passes through the transformers is also sent through the rheostats. When operating on alternating current the transformer is heating the air which passes through, and this air would not be very effective in cooling the rheostat. However, when running on direct-current the transformer is idle, and the air passing through becomes effective in the rheostat.

In addition to the above auxiliary apparatus there are oil circuit breakers for the high tension alternating-current switches for throwing from alternating to direct current, and many details which would be found in any electric locomotive. There is also a steam generator in the cab for the purpose of generating sufficient steam for heating the coaches in cold weather.

The locomotive is equipped with devices for collecting both alternating and direct current For the latter there are eight collecting shoes, four on each side of the locomotive, arranged in pairs of two each. There are, of course, two pairs on each side, one at each end, for the purpose of bridging such gaps as are necessary in the third rail system. There must be shoes on each side, as the locomotive must be able to make contact with the third rail when turned end about. These direct-current contact shoes must also be able to work on two forms of third rail, one in which the shoe runs under the rail and the other where the shoe runs on top of the rail. The locomotive is provided with a pantagraph low-tension overhead direct-current trolley to conform with certain New York Central requirements.

For collecting alternating-current the locomotive is provided with two pantagraph type high-tension bow trolleys. Each trolley has a capacity to carry the total line current under average conditions, but two are provided to insure reserve capacity.

Each of these locomotives is to be able to handle a 200-ton train in local service on a schedule of 26 miles per hour, with stops averaging about two miles apart. In order to make this average speed the maximum speed will be about 45 miles per hour. One locomotive will also be able to handle a 250-ton train on through service. For heavier trains than this it is intended to couple two locomotives together and operate them in multiple. This presents no difficulties, for, as stated before, the locomotives are fitted up for the multiple unit system of control.

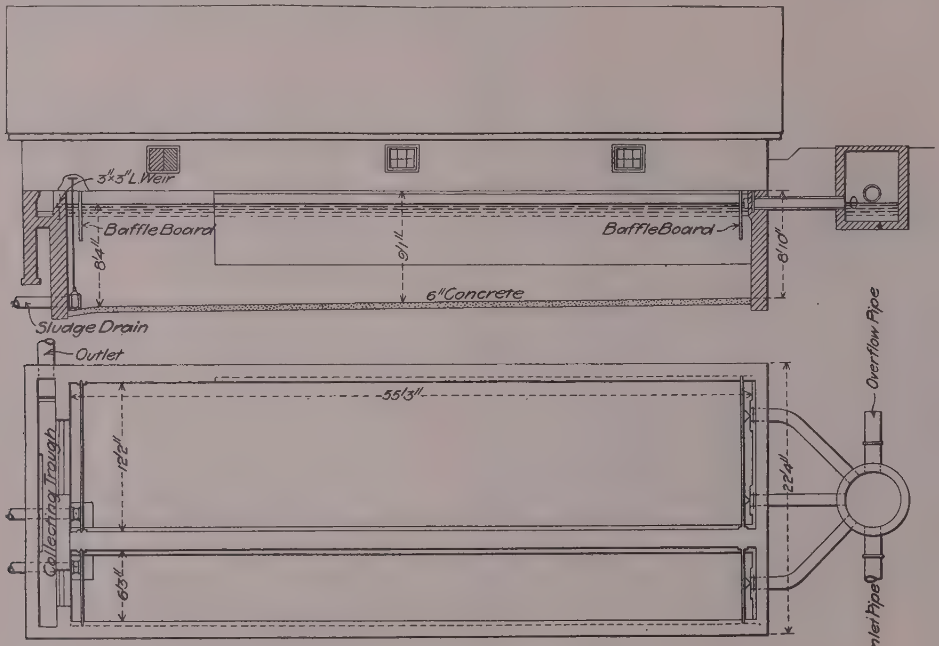
Bridge Travel in New York City.

East River bridge travel in New York is referred to as follows in the report for 1905 of ex-Commissioner Best of the Bridge Department: "While the Brooklyn bridge has not gained materially in travel during 1905, the Williamsburg bridge is to-day transferring about one-third the total number of passengers carried over the Brooklyn bridge and 70 per cent. of the number of passengers carried in trolley cars over the old bridge. A great portion of the travel on the Williamsburg bridge is taken from ferries, but a large portion of it must be new business created by the existence of the bridge itself. It is evident that if more lines of Brooklyn cars could be run over the bridge the number of passengers transported would be greatly increased, with definite relief to the Brooklyn bridge." The Brooklyn bridge congestion cannot be relieved under existing conditions until the Manhattan bridge is put in service, for, as Mr. Best states, "the limit of train operation in the present Manhattan station during rush hours has been reached," and other transportation facilities cannot be materially improved until the bridge is rebuilt.

The Sewerage System of Centerville, Iowa.

Centerville, Iowa, has a population of approximately 6,000, and prior to 1903 had as little in the way of municipal improvements, according to its size, as any other town in the State. Since that time a large stone courthouse and a number of modern business buildings have been erected, while the city has constructed, or placed under contract, pavement and sewer work amounting to $225,000. The water-works plant, which is owned by a private company, has also been improved during the past three years until now an abundant supply of good water is available. The sewerage system, which had to be designed to meet rather difficult topographical conditions, was described in a paper by Mr. Arthur J. Cox before the recent meeting of the Iowa Engineering Society. The following notes on the design, construction and cost of the system have been taken from that paper, the illustrations having been furnished by Mr. Cox:

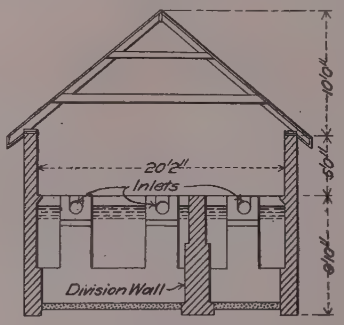
The town covers an area 2 miles long by 1¼ miles wide, and is rather sparsely built along a high ridge of ground extending from northwest to southeast. This ridge is buttressed by heavy lateral ridges extending east and west and separated from each other by deep ravines. The site of the town is thus divided into two drainage areas, one having its outlet to the west, and the other, comprising more than three-fifths of the built-up section, draining to the east. The drainage of the entire town site ultimately reaches a creek which flows north along the west side of the dividing ridge, and then east beyond the northern limits of the town to the Chariton River. The topography is such, however, that the sewage of the town cannot be brought to one outlet without excessive and unwarranted expense. The cross ridges and ravines further complicated the design of the sewerage system. It was found cheaper and more satisfactory to make use largely of the natural fall of the surface and provide several outlets, each serving some natural drainage area of the city. The fall from the center of the town to a small stream on the east side of the ridge is 120 ft. in less than a mile, and about the same on the west side, so that one main outfall sewer was practically out of the question. An important advantage was also obtained in making several drainage districts, each with an outfall sewer, in that those areas that are most sparsely built up, where the need of sewerage is not urgent, can be sewered as the necessity becomes more pressing, without entailing the expense required to provide for them at present with one main outfall for the entire town.



Plans and Sections of Centerville Septic Tank.

The town is divided into eight drainage areas, each having an outlet, the areas being designated for engineering reasons only, as the town is embraced in one large sanitary district in order to simplify legal questions. The sewage of three of these areas, comprising the business district and the greater part of the residence portion is carried to one disposal plant northeast of the town. The sewerage of these areas required the construction of 17.1 miles of sewers and a septic tank. Thirteen miles of sewers and the septic tank have been completed. The sewerage system for only one of the five remaining areas has been built, the construction of the systems for the other areas having been delayed until required. The system of this fourth area includes 2.14 miles of pipe sewers and a septic tank, but the construction of the latter has been postponed.

A separate system for domestic sewage only has been adopted for two reasons. First, because a combined system would have cost more than the available funds would provide, and furthermore, such a system was not considered necessary owing to the sufficient natural grade on most of the streets to carry away storm water. Second, the location of the town requires all of the sewage to be treated, ultimately, so the more limited the amount of sewage the greater the economy in disposal.



The location and construction of the outlets required some careful design owing to the rugged and uneven topography of the surrounding country. The outlets are necessarily on hillsides, so the septic tanks could easily be kept above the streams into which the final effluents must be discharged. In keeping on these hillsides it was necessary in several places to cross ravines or creek beds above the natural surface of the ground. One outfall sewer is carried over a waterway through a steel pipe on masonry piers, while the drainage from smaller ravines is carried under the sewer in pipe culverts. Another outfall crosses several water courses which discharge into ponds that supply a railroad watering tank. These submerged crossings are made in 12-in. hub and spigot cast-iron water pipe with lead joints. Owing to the soft foundation encountered and to the current of the streams, the pipe in most of the crossings is placed on concrete piers carried down to firm foundation. Other than these crossings mentioned, the sewers are all vitrified clay pipe, varying from 8 in. to 15 in. in diameter.

The prices at which all of the work was let proved very favorable to the city. Judged from the surface of the ground before work was commenced, the appearances were that the contractors would have few difficulties in laying the sewers. When the ditches were opened, considerable trouble was experienced from running water, in places, particularly on one street where saddle piles had to be driven and the pipe laid on 2-in. plank. The greatest disappointment, however, was in the character of the soil. When first opened up the sides of the ditches had the appearance of stability, but they caved badly soon after the excavation was made. Much of the trench work was in very hard ground, in some places hard shale, where pick work was constantly required. A large part of the trench work, specially in the lower sewers, encountered innumerable hard limestone pebbles and boulders from the size of a hen's egg up. These were not, however, of sufficient size or quantity to be classed as solid rock, but they interfered with spading and proved very expensive to move.

All of the excavating in one area was done by hand labor, while that in two of the other areas was done both by hand and with a Chicago sewer trench excavator made by the Municipal Engineering & Contracting Co. The cost of laying different sizes of vitrified pipe in trenches dug by hand through the various soils encountered is shown in the accompanying tables. The results in these tables were very accurately kept and are believed to be a good example of the cost of such work. Under favorable conditions the trenching machine dug ditches 32 in. wide and from 9 to 14 ft. deep at the rate of about a lineal foot a minute, but this high rate could not, of course, always be kept up. During the 66 days that the machine was in use in the same area in which the cost of hand work is covered by the accompanying tables and under practically the same conditions, it made an average of 200 lin. ft. of trench a day of 10 hr., this rate taking into account delays of various kinds due to moving, repairs, and accidents. Some of the best records were 350 to 400 ft. a day, while the highest rate made was 275 ft. in 145 minutes, the trench average 11 ft. deep.

Cost tables of the machine work at Centerville have not been completed, Mr. Cox stated, but the experience with the machine developed the following points. The highest rates of speed and the best work is naturally done on solid ground where the grade of the surface is nearly uniform. The hardness of the earth encountered makes little difference in the progress of the machine, pebbles and stones being easily taken out, if not solidly cemented together. The depth of the trench (9 to 15 ft.) does not materially affect the rate of progress, although the best results seem to have been obtained at 11 ft. The machine should be operated by a crew of men thoroughly trained to attend to their respective duties. With the machine in good condition and properly operated, the trench can be kept in good line.

The outfall sewers discharge into small streams which, although they have some water flowing in them at all seasons of the year, do not carry a sufficient volume to dilute the crude sewage enough to render it entirely inoffensive. The ultimate plans for the disposal of the sewage contemplate filtration subsequent to septic tank treatment. For the present it is considered sufficient to use the septic tank treatment alone in the three drainage areas which comprise the most important part of the town and to postpone the construction of a tank for the other area that has been sewered. This tank is placed at the end of the outfall sewers from the three areas and near the creek into which the effluent from it is discharged. There is ample room for constructing filter beds and additional septic tanks adjacent to it.

The septic tank has a capacity of 60,000 gal., or about 8 hr. flow when the present system, which it serves, is developed. It has a concrete bottom, and side walls of very hard burned brick laid in Portland cement mortar, with all inside surfaces plastered. One wall is built on a ledge of rock. The tank is divided in two compartments, one with a capacity of 20,000 and the other of 40,000 gal. The dimensions and arrangement of the tank are shown in the accompanying reproduction of the plans. The sewage level is 8 ft. above the bottom of the tank at the outlet

Sewer Trench Machine at Work.

TABLE 1.—LABOR COST OF DIGGING TRENCH, LAYING PIPE AND BACKFILLING IN AREA NO. 1.

Length, ft.	Size pipe, ins.	Ave. cut, ft.	Max. cut, ft.	Min. cut, ft.	Trench diggers, hr.	Pipe layer, hr.	Helpers, hr.	Foreman, hr.	Water boy, hr.	Cost of trench and laying per ft., dol.	Two men and team, backfilling, hr.	Backfilling by hand, hr.	Cost of backfilling, dol.	Cost of labor per ft. trench, dol.	Cement used 1 to 1 mortar.	CONDITIONS GOVERNING WORK.
...	..	..	...	..	.18	.30	.17½	.35	.12½	..	.52½	.17½	..	..	....	Wages per hour.
296	15	5.6	11.0	0.8	177	16	33	15	15	.164	7	28	.029	.693	160′ 1 bbl.	Very easy digging in black loam.
523	15	6.7	7.8	5.9	1,408	57	102	61	60	.603	35	97	.067	.670	192′ 1 bbl.	Difficult and slow work, 1,050 cu. ft. of rock.
376	15	7.3	11.3	3.4	366	24	48	35	35	.260	7	37	.027	.287	284′ 1 bbl.	Easy spading in black soil.
592	15	7.5	12.1	3.2	645	37	74	44	44	.272	19	100	.046	.318	230′ 1 bbl.	Clay, good spading, little water in ditch.
326	15	7.4	9.6	6.2	590	33	66	50	50	.464	24	69	.075	.539	154′ 1 bbl.	Difficult and slow work, 262 cu. ft. of rock.
424	12	4.9	6.3	3.9	109	31	62	6	60	.428	..	39	.016	.444	...	Hard work, 662 hr. on 1,164 cu. ft. of rock in ditch, 92½ lbs. dynamite.
449	12	6.5	8.2	5.3	421	35	70	40	40	.262	18	57	.043	.305	9	Easy spading in black soil, wet and bad weather.
333	12	8.0	14.0	1.5	726	49	94	30	60	.540	10	74	.055	.595	...	Good clay digging, bad weather and ditch caved.
246	12	8.4	11.4	6.3	320	15	30	15	15	.302	4	28	.028	.330	4¼	Fine clay spading, little water in ditch.
373	12	9.0	10.5	6.8	557	47	94	47	47	.410	29	99	.087	.497	3½	Moderate clay spading; crossed car track twice.
256	12	9.2	11.0	8.4	415	27	54	14	14	.387	8	68	.063	.450	5¼	Good clay digging, dry and hard sandy bottom.
440	12	9.4	14.4	5.3	899	40	80	30	40	.462	25	78	.061	.523	...	Good clay work, sandy, 100 ft. wet ground filled with bats.
352	12	9.6	12.4	5.7	840	59	111	59	59	.614	14	81	.061	.675	8	Good clay spading, wet weather made ditch cave.
106	12	9.9	12.0	8.7	448	10	20	26	36	.950	7	10	.051	1.001	...	Boulders in ditch, wet ground, 12 ft. concrete under bridge.
230	12	10.1	10.5	9.6	537	22	44	50	40	.580	35	87	.146	.726	4	Good clay spading, dry sandy bottom.
241	12	11.5	15.2	9.5	904	44	73	26	30	.836	4	105	.085	.921	5¾	Hard pan pick work in boulders, 60 ft. concreted pipe.
496	12	11.7	13.5	7.3	1,636	57	99	79	79	.738	22	79	.051	.799	9½	Layer of boulders in trench 2 ft. thick, pick work.
256	12	14.2	17.4	9.0	1,408	41	82	100	100	.889	22	56	0.83	.972	...	Very hard pick work in shale, rainy weather.
348	12	10.3	15.2	6.9	1,053	36	69	38	38	.662	8	123	.074	.736	184′ 1 bbl.	Hard digging in rocky ground, 80 ft. con. pipe, 13 sks. cem., 4 yds. rock, 5.4 yds.
215	12	10.9	12.2	9.9	406	25	45	39	39	.498	19	30	.070	.568	4¼	Filled ground, wet ditch, concreted pipe under bridge.
252	10	7.6	9.1	6.5	206	20	40	20	20	.236	7	27	.033	.269	3½	Fine clay spading, wet ditch with sandy bottom.
258	10	8.6	10.1	7.2	296	21	42	29	29	.313	23	73	.096	.409	4½	Good clay digging, narrow street crowded.
209	10	9.7	10.1	8.9	339	28	47	44	44	.471	..	47	.039	.510	2¼	Close to street car track, dirt handled twice.
122	10	10.0	...	..	260	18	36	20	20	.554	..	53	.076	.630	2¾	Clay work, cramped quarters, dirt handled twice.
206	10	10.0	...	..	437	30	60	30	30	.545	..	166	.141	.686	4¼	Cavey ground, close to street car track, dirt shoveled twice.
240	10	10.6	11.8	8.4	653	37	42	60	60	.685	..	144	.105	.790	6½	Street car track, 144 hr. moving steel, close to gas tank.
123	10	10.9	...	..	462	23	46	37	37	.940	..	108	.154	1.094	3	Street car track, wet weather made very bad ditch.
471	10	11.7	14.1	10.7	1,239	92	120	100	100	.677	..	367	.135	.818	8	Moderate digging in clay, crossed street car track.
246	10	12.0	...	..	659	30	60	33	33	.625	..	159	.113	.738	4¾	Good clay work, but crowded quarters, dirt handled twice.
376	10	12.2	13.1	10.2	900	65	130	75	75	.638	..	239	.111	.749	7	Good clay spading, 50 ft. wet ditch, service pipes.
128	10	12.2	...	..	541	36	64	40	40	1.081	..	74	.101	1.181	2	Spading hard, lost 100 ft. of ditch from bad weather.
228	10	10.6	...	..	449	25	50	29	29	.486	4	56	.052	.538	4⅔	Moderate clay spading, cavey ditch, 33 ft. street.
237	10	11.2	16.0	7.3	763	36	60	25	25	.719	5	170	.136	.855	4⅔	Rocks in ditch, bad weather for deep ditch.
230	10	11.3	12.0	10.0	552	17	34	11	11	.500	23	73	.108	.608	4¼	Good clay spading, dirt handled twice, 33 ft. street.
196	10	11.3	12.7	10.2	381	27	40	40	40	.524	..	94	.084	.608	2¼	Hard clay spading, cramped quarters, 33 ft. street.
259	10	12.7	13.5	11.5	757	22	40	9	20	.600	11	39	.049	.649	2½	Moderate clay spading, 33 ft. street, dirt handled twice.
784	8	9.2	10.5	7.6	1,165	47	94	51	51	.337	23	161	.051	.388	6¾	Fine clay spading, 100 ft. wet ditch, dry weather.
199	8	9.7	10.6	9.1	252	21	32	30	30	.359	..	52	.045	.404	2	Fine clay spading, dry.
96	8	10.5	...	..	234	22	27	20	20	.655	..	104	.186	.841	2	Hard digging, wet weather, made slopy backfilling.

TABLE 2.—LABOR COST OF DIGGING TRENCH, LAYING PIPE AND BACKFILLING IN AREA NO. 2.

Length, ft.	Size pipe, in.	Ave. cut, ft.	Max. cut, ft.	Min. cut, ft.	Trench diggers, hr.	Pipe layer, hr.	Helpers, hr.	Foreman, hr.	Water boy, hr.	Cost of trench and laying per ft., dol.	Two men and team, backfilling, hr.	Backfilling by hand, hr.	Cost of backfilling, per ft., dol.	Cost of labor per ft. trench, dol.	Cement used 1 to 1 mortar.	CONDITIONS GOVERNING WORK.
...	..	..	..	..	.18	.30	.17½	.35	.12½	...	.52¼	.17½	...	...	..	Wages per hour.
385	15	6.5	9.5	5.4	412	38	76	65	50	.332	..	..	...	...	4½	Good spading in black soil, small boulders, no pipe.
221	15	7.7	8.9	6.7	135	20	40	20	20	.211	15	34	.061	.872	..	Fine easy spading, hauling 15-in. pipe 1½ miles, costs 1¼ ct. ft.
206	15	8.9	13.0	6.1	547	29	58	70	60	.724	14	27	.059	.783	..	Good spading, 2 ft. hard pan in bottom, ditch caved, 16 ft. wide.
446	15	9.0	13.0	5.7	1,107	85	170	169	100	.731	15	63	.042	.773	..	Good clay spading, 2 ft. shale in bottom; ditch caved bad.
216	16	3.5	9.0	.0	90	0	96	...	..	.238	10	5	.028	.266	..	Brick mason 10 hr., tenders 20 hr. on piers, plumbers 19 hr. at 60c. per hr.
271	12	7.7	12.0	5.9	297	25	50	32	30	.312	..	..	...	...	3½	Easy clay spading 50 ft., wet ditch.
446	12	8.2	11.3	3.5	792	64	128	105	105	.525	..	..	...	...	..	Easy spading, boulders in ditch, 13 yds. blasted rock.
309	12	8.2	12.5	5.7	336	33	66	30	30	.311	15	..	.025	.356	..	Good spading in loam and clay, small rocks in ditch.
221	12	8.6	11.2	7.0	298	25	48	10	10	.336	16	19	.055	.391	3½	Filled ground, wet and caved badly.
272	12	9.6	15.3	7.2	469	45	90	47	40	.497	16	50	.063	.560	..	Cavey ground, concreted pipe under bridge, 15 hrs., 1⅓ yds.
595	12	10.7	17.3	5.7	1,093	72	145	78	78	.472	9	48	.022	.494	6½	Good clay spading, concreted pipe, 15 hrs., 1⅓ yds.
246	12	11.0	17.1	4.5	564	54	106	33	33	.617	..	107	.075	.793	..	Very easy clay spading, 50 ft., wet ditch, bad weather.
344	10	7.0	9.9	3.6	156	19	36	19	19	.143	..	92	.047	.190	..	Fine soft spading, 25 ft., wet ditch, sandy bottom.
331	10	12.0	16.3	8.2	863	53	106	5	40	.594	..	..	...	...	3⅓	Good spading in sandy clay, dry ditch.
331	8	6.3	9.8	3.2	281	21	42	21	21	.224	8	14	.020	.244	4½	Easy spading in black swampy ground, 125 ft., wet.
436	8	7.3	12.8	2.9	485	23	46	2	20	.242	9	45	.029	.271	2½	Fine clay spading, 50 ft. wet ditch, slopy backfilling.
339	8	7.3	9.1	4.7	348	26	52	30	30	.276	..	..	...	...	3⅓	Good clay spading, small rocks in ditch, 100 ft., wet.
296	8	7.8	9.3	6.6	218	19	38	19	19	.204	22	4	.041	.245	3½	Very fine clay spading, sandy bottom, 75 ft., wet.
361	8	8.1	10.5	5.9	497	31	62	35	35	.349	33	7	.051	.406	2½	Spading in hard clay, small boulders and boose.
582	8	8.1	10.1	5.6	710	35	68	31	31	.283	22	31	.039	.312	4¾	Very soft, easy spading in loam and clay, dry ditch.
1,700	8	8.2	11.0	3.5	2,460	138	276	170	170	.349	119	225	.059	.408	9	One-half hard digging, small boulders in ditch, 5 yds. blasted.
276	8	8.6	10.9	6.6	318	28	56	1	20	.284	4	26	.028	.312	3	Very easy spading in yellow clay, 100 ft. wet ditch.
546	8	8.9	10.1	8.0	708	32	64	0	30	.277	20	26	.027	.304	3	Close to street car track, but good clay spading, bottom wet.
186	8	9.0	..	..	259	15	30	0	20	.316	5	7	.021	.337	2	Hard clay spading, dry, no boss.
296	8	9.0	9.8	8.5	407	35	70	40	40	.388	13	10	.029	.417	4¼	Close to street car track, clay spading hard, dry ditch.
690	8	9.1	11.7	7.5	855	55	110	59	59	.315	..	..	...	...	4½	Good spading, 100 ft. wet and sandy, all sheated tight.
415	8	9.1	12.1	5.7	914	56	112	30	50	.570	15	130	.073	.643	5	Dipping water 60 hr., 174 ft. lumber left, 50 ft. quicksand.
359	8	9.2	10.7	7.8	415	46	92	42	42	.347	42	34	.077	.424	3¼	Good clay spading, but hard and dry.
222	8	9.3	9.7	8.9	289	25	50	4	20	.325	11	8	.032	.357	2½	Good clay spading, sand, dry bottom.
396	8	9.5	10.0	8.7	473	24	48	30	30	.290	31	11	.046	.336	2	Good clay spading, dry and hard, muddy backfilling.
429	8	9.5	11.2	5.8	484	32	64	35	35	.290	29	31	.048	.338	3¾	Good clay spading, 100 ft. wet ditch, crowded quarters.
411	8	9.5	10.4	8.7	636	30	60	30	30	.360	19	13	.029	.389	6¼	Good yellow clay spading, hard and dry.
1,290	8	9.6	10.5	8.3	2,099	115	230	14	115	.365	84	31	.038	.403	10	Good spading in clay, hard and dry under trees.
391	8	9.6	10.7	8.4	532	28	56	28	28	.325	21	29	.041	.366	2¼	Moderate clay spading, dry bottom.
371	8	9.7	10.3	9.1	515	45	90	45	45	.386	26	0	.037	.423	4	Close to street car track, but good clay work, car track crossed street.
578	8	9.8	11.0	9.1	995	56	112	6	50	.387	41	..	.037	.424	5⅓	Close to street car track, good spading, under switch.
369	8	9.9	11.5	7.9	627	33	66	33	33	.406	24	28	.047	.453	..	Ditch caved badly, close to old water pipe ditch.
441	8	10.0	..	..	686	35	70	4	35	.344	27	..	.032	.376	3⅓	Close to street car track, but easy spading in clay.
221	8	10.0	11.6	8.3	277	18	36	3	15	.292	13	..	.031	.323	1⅔	Very easy clay spading, dry.
907	8	10.0	11.2	8.2	1,244	81	162	79	79	.345	38	38	.029	.374	14	Easy clay spading, dry ditch, 100 ft., rainy weather.
352	8	10.1	10.7	9.7	521	39	78	5	35	.356	2	104	.054	.410	..	Easy clay spading, but tight quarters.
446	8	10.1	11.3	8.3	964	66	132	62	62	.551	28	16	.039	.590	7¾	Very hard digging, all pick work, dry ditch.
376	8	10.1	11.3	9.1	570	31	62	40	40	.377	31	47	.065	.542	2⅔	Good dry clay digging, dry and hard, 33 ft. street.
371	8	10.3	11.1	8.6	356	29	58	29	29	.260	22	13	.036	.296	..	Good clay spading, hard and dry, 33 ft., street.
221	8	10.4	11.0	9.5	389	27	54	..	25	.410	..	..	...	...	1⅔	Easy spading in clay ground.
79	8	10.4	11.4	8.9	131	9	18	..	5	.380	12	23	.130	.510	1	Easy spading in sandy clay, muddy backfilling.
493	8	10.6	11.2	10.2	936	60	120	33	50	.457	23	..	.024	.481	5	Close to street car track, under reversed curve, dry.
351	8	10.6	12.9	6.6	475	25	50	25	25	.324	24	20	.045	.369	3¼	Good digging in sand and clay, 10 ft. wet.
358	8	10.7	12.2	9.1	546	30	60	30	50	.368	..	..	...	...	..	Good clay spading, but hard and dry.
361	8	10.8	11.7	10.0	768	51	102	..	50	.492	36	32	.063	.560	2¼	Hard clay spading, men dissatisfied over pay.
261	8	10.8	11.9	9.7	387	31	62	30	30	.392	30	38	.080	.472	2¼	Easy clay spading, dry and sandy bottom.
437	8	11.5	12.9	9.8	776	60	120	60	60	.474	4	27	.096	.570	10¾	Easy spading in sandy clay, 50 ft. very wet sand.
352	8	11.6	12.4	8.9	934	67	134	1	60	.623	..	..	...	...	3½	Hard clay, pick work, men drinking; no boss.

TABLE 3.—TOTAL COST PER LINEAR FOOT OF COMPLETED SEWER IN AREA NO. 3.

Length, ft.	Size pipe, in.	Width of trench, in.	Max. cut, ft.	Min. cut, ft.	Average cut, ft.	Trenchers, bottom lift, hr.	Trenchers, top lift, hr.	Bailing, hr.	Pipe layer, hr.	Helpers, hr.	Foreman, hr.	Water boy, hr.	Flushing, hr.	Backfilling by hand, hr.	Two men and team, backfilling, hr.	Labor cost per foot trench, cents.	Cost of pipe per ft., cents.	Cost of cement, per foot, cents.	Total cost per foot of trench, cents.	Contract price, cents.	CONDITIONS GOVERNING WORK.
Wages: Cents per hour.						17	17	..	30	15	35	10	..	16	52½	...	...	..	...	..	
177	8	22	7.4	4.7	6.0	60	9	..	5	10	10	16	..	14	2	13.0	13.6	0.5	27.1	53	Soft, easy spading.
368	8	24	14.3	7.4	12.1	600	131	..	20	39	27	27	..	82	28	47.8	13.6	0.5	61.9	53	Dry, hard clay; very hard spading and pick work.
361	8	22	11.6	4.2	7.2	282	22	..	12	24	9	9	..	92	..	21.6	13.6	0.5	35.7	53	100 ft. hard spading; rest soft, easy spading.
300	8	22	14.5	9.5	12.4	600	182	..	27	54	25	27	..	85	14	86.5	13.6	0.5	100.6	53	Very dry and hard; hard pick and spade work.
727	8	22	12.9	.0	7.5	600	142	..	45	91	50	50	..	57	22	26.9	13.6	0.5	41.0	53	Very dry and hard; hard pick and spade work.
280	8	22	11.8	9.9	10.3	320	141	..	23	42	27	27	..	42	17	42.7	13.6	0.5	56.8	53	Very dry and hard; hard spading; joint clay.
300	8	22	12.1	9.6	11.2	365	144	..	26	26	23	24	..	78	9	41.8	13.6	0.5	55.9	53	Very dry and hard; hard spading; joint clay; rain caused bad caving.
Wages: Cents per hour.						20	17½	..	30	18	44.4	8⅓	..	17½	59	...	...	..	...	..	
427	12	24	16.0	6.1	9.6	462	118	..	42	80	42	46	..	54	11	42.3	26.0	0.5	69.2	64	200 ft. hard yellow mottle clay; 227 ft. soft loam; 25 ft. culvert, wet ditch.
352	10	22	11.6	5.7	10.1	322	130	..	23	46	26	26	..	42	21	34.6	20.0	0.6	55.2	64	Yellow, sandy clay bottom; easy spading; dry, hard gumbo top.
360	10	22	13.6	6.1	10.2	422	211	..	22	44	26	26	..	51	11	45.5	20.0	0.6	66.1	64	Do. with above; 3 ry. tracks in 13-ft. cut, tunneled.
363	10	22	14.3	5.4	9.5	272	145	..	34	71	40	34	..	70	10	36.2	20.0	0.6	56.8	64	2 ry. tracks in 14-ft. cut, wet bottom; easy spading.
360	8	22	9.2	4.3	6.6	153	45	..	15	20	9	9	..	41	3	16.7	13.6	0.5	30.8	53	Soft, easy spading.
370	10	22	15.8	4.5	9.0	418	222	..	34	42	47	47	..	17	8	46.3	20.0	0.6	66.9	64	150 ft. hard clay; seam of water-bearing sand near top; rest hard, joint clay.
367	8	22	12.1	8.5	11.2	487	177	..	34	68	37	37	..	61	21	62.7	13.6	0.5	66.8	53	Hard, dry clay, mostly joint clay.
252	8	22	10.8	8.5	9.5	240	103	..	20	40	19	19	8	37	16	40.6	13.6	0.5	54.7	53	Hard, dry clay, mostly joint clay.
359	8	22	13.4	8.5	12.1	462	237	..	29	58	30	30	10	77	22	55.0	13.6	0.5	69.1	53	Hard, dry clay, mostly joint clay.
300	8	22	13.2	9.4	11.1	448	128	..	29	57	30	30	8	42	33	51.5	13.6	0.5	65.6	53	Hard, dry clay, mostly joint clay.
328	10	22	14.6	1.8	8.0	191	140	..	21	38	18	18	..	..	15	48.0	20.0	0.6	68.6	64	Easy spading; 100 ft. wet bottom.
426	8	22	11.6	7.5	8.8	321	162	..	20	39	24	24	..	51	24	32.5	13.6	0.5	46.6	53	Easy spading; dry joint clay.
243	8	22	11.1	7.6	8.7	190	83	..	19	38	8	8	4	7	8	31.2	13.6	0.5	45.3	53	1 6-ft. tunnel; 100 ft. had 6 ft. made dirt; rest easy spading.
388	8	22	11.1	8.9	10.4	399	144	..	24	48	29	29	..	44	25	41.0	13.6	0.5	55.1	53	Good spading; gumbo and joint clay.
406	10	22	14.8	10.6	12.6	459	264	25	46	64	48	48	8	48	22	52.8	20	0.6	73.4	64	3 ry. tracks; 3 tunnels 9-ft. long; gumbo.
377	10	22	12.0	4.6	8.8	330	120	..	34	66	28	28	..	186	9	42.8	20	0.6	63.4	64	2 10-ft. tunnels under St. car track; easy spading along Ry. fill.
426	8	22	11.2	4.1	6.9	263	57	..	19	38	16	16	..	15	13	22.0	13.6	0.5	36.1	53	Easy spading in gumbo.
612	8	22	13.6	6.8	11.8	769	341	..	57	102	64	63	..	122	31	52.6	13.6	0.5	66.7	53	Hard spading in joint clay; banks slide.
285	8	22	9.5	6.8	8.6	207	69	..	15	30	11	13	..	12	12	27.5	13.6	0.5	41.6	53	Joint clay, dry and hard.
675	8	22	10.8	8.2	9.6	576	365	..	47	94	59	56	..	18	36	39.3	13.6	0.5	53.4	53	Gumbo, dry and hard.
610	8	22	12.5	10.5	11.6	621	372	..	52	96	62	53	..	96	37	47.9	13.6	0.5	62.0	53	Joint clay and gumbo; dry and hard.
200	8	22	10.5	9.4	9.8	197	78	..	13	22	13	15	..	2	9	36.7	13.6	0.5	50.7	53	Joint clay and gumbo; dry and hard.
237	8	22	14.6	11.9	13.5	422	185	..	21	34	42	42	..	115	5	73.4	13.6	0.5	87.5	53	Joint clay, 3 30-ft. tunnels under C., R. I. & P. crossing.
537	8	22	7.7	5.1	5.8	249	103	..	18	36	19	19	..	10	22	19.5	13.6	0.5	33.6	53	Gumbo; easy spading.
Wages: Cents per hour.						20	17½	..	30	20	35	..	..	17½	52½	..	..	..	..	..	
171	12	24	9.6	3.6	7.6	277	..	..	20	38	45	..	..	72	..	56.4	26.0	0.7	83.1	64	Easy spading; rock in ditch.
316	12	24	21.3	4.3	12.2	1,229	..	..	80	85	71	..	..	143	..	106.8	26.0	0.7	133.5	64	Very hard shale and rock; pick work and blasting.
208	12	24	17.4	9.6	13.1	570	145	..	42	40	60	..	..	130	..	97.4	26.0	0.7	124.1	64	Very hard shale and rock; pick work and blasting.
234	12	24	14.7	6.1	11.0	490	110	..	38	45	35	..	..	69	5	70.7	26.0	0.7	97.4	64	Moderate spading.
371	12	24	12.5	3.9	8.1	525	76	..	32	52	45	..	..	26	22	45.7	26.0	0.7	72.4	64	Easy spading.
246	12	24	10.9	3.1	8.3	379	57	..	27	53	26	..	..	72	15	50.6	26.0	0.7	77.3	64	Easy spading.
406	12	24	18.7	0.7	12.3	630	279	..	54	109	49	..	..	26	13	58.9	26.0	0.7	85.6	64	Easy spading.
421	12	24	11.3	5.5	8.9	559	78	..	30	59	30	..	..	73	19	41.4	26.0	0.7	68.5	64	Easy spading.
338	12	24	9.2	5.9	7.6	388	63	..	17	34	17	..	..	85	4	35.0	26.0	0.7	61.7	64	Easy spading, wet. 65.6 yds. of rock on outlet.

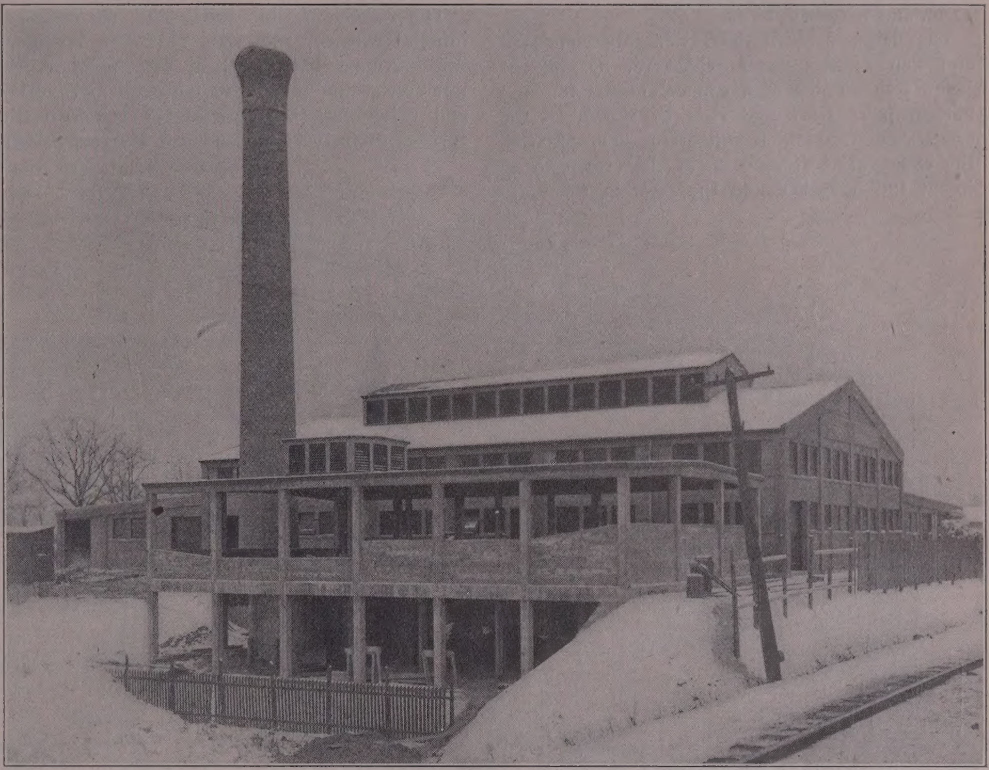
end. The outfall sewers from the three areas join near the tank and discharge into a 4.5-ft. circular brick well at the inlet end of the tank. The heavy inorganic materials brought down in the sewage will be intercepted in this well. Three 10-in. outlets lead from the circular well, one connecting with the smaller and the other two with the larger compartment as shown. The ends of these pipes in the tank are submerged about one-half at the normal water level in the latter. The sewage as it is discharged from the inlet pipe is deflected down into the tank by baffle boards extending across the compartments. The effluent from the tank passes from the compartments under baffle boards similarly arranged at the outlet end, so that the scum on the surface of the water in the tank will not be disturbed by currents. After passing under the baffle boards at the outlet end, the effluent passes over weirs made of steel angles, into a transverse collecting trough, thence over a measuring weir in the latter to an outlet leading to the creek. An 8-in. sludge blow-out extends from each compartment of the tank to an old pit near the latter. The brick inlet well has an overflow connected with a 15-in. by-pass around the tank, which joins the outlet pipe from the latter to the creek. The tank is covered by a brick building with an iron roof. The complete cost of the tank, including $363 for rock excavation, was $3,021, but not allowing for land, right-of-way, engineering and inspection.

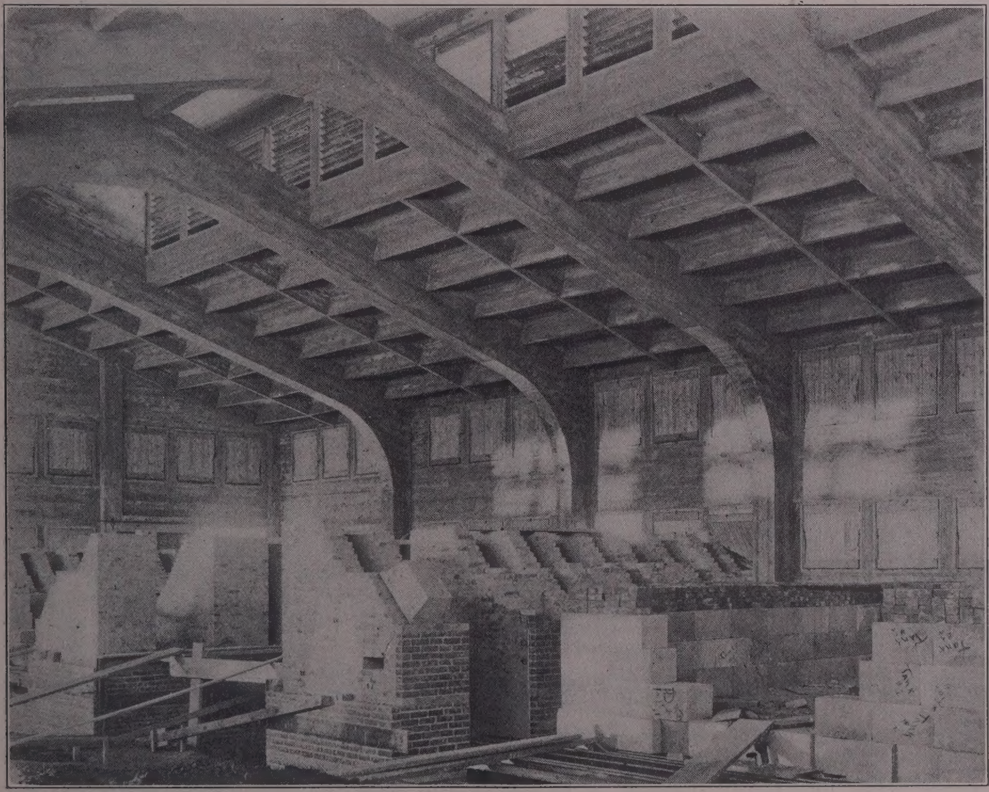
The cost of the sewers in the three areas which this tank serves, exclusive cost of the septic tank, right-of-way, engineering, inspection, printing and cost of making assessments, was $50,902.51, according to contract. The work embraced 3,758 ft. of 15-in., 12,418 ft. of 12-in., 10,940 ft. of 10-in. and 40,527 ft. of 8-in. pipe, 130 manholes, 22 drop manholes, 51 flush tanks, 305 cu. yd. of rock excavation, 2,510 ft. of ¾-in. lead pipe flush tank connections, with a total of 12.81 miles of sewers, making the cost $3,974 per mile, excluding the items noted. The remaining area in which the sewers have been built, including 3,728 ft. of 12-in., 1,032 ft. of 10-in., and 6,533 ft. of 8-in. pipe, 28 manholes, 6 drop manholes, 5 flush tanks, 128 cu. yd. of rock excavation, $10,242.88, or a total of 2.14 miles, cost $4,786 a mile, as per contract, excluding the same items noted as being excluded under the other three areas. The trench work required in all cases is indicated by the notes in the accompanying table. The cost of labor and other conditions governing the total cost are also indicated in the table.

The sewerage system was designed by and the construction of the portion of it that has been completed was supervised by the Iowa Engineering Co., of Clinton, Iowa.

The Northwestern Ohio Bottle Company's Factory.

The factory of the Northwestern Ohio Bottle Co., at Toledo, O., has a main building and coal shed of the Ransome reinforced concrete construction. The former is an irregular 142x149-ft. rectangular structure which consists of four buildings of different heights and dimensions compactly arranged on a nearly square area. The most interesting one is the 64x49 ft. furnace room, which has a total height of about 52 ft. above the lowest footings. It is of special interest on acount of the massive roof girders or rafters, shown in the general cross section, which are among the longest spans of reinforced concrete beams, and are made integral with the wall columns so as to form complete transverse bents 16 ft. apart on centers.

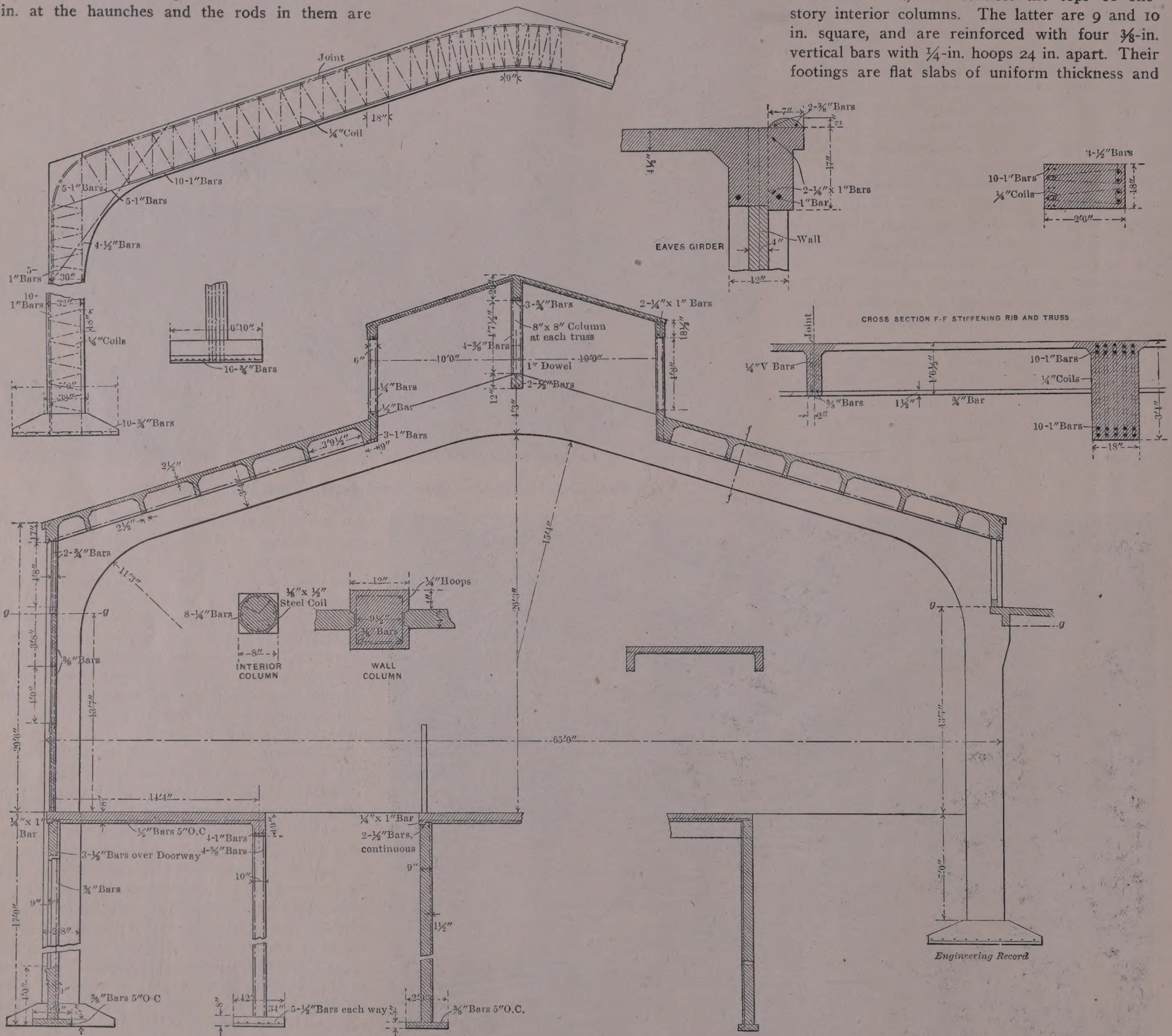

Reinforced Concrete Coal Shed, Northwestern Ohio Bottle Works.


Roof of Sixty-five Foot Span, Northwestern Ohio Bottle Works.

The columns on one side of the building are 37½ ft. high from the footing to the eaves, and on the other side are about 8 ft. shorter. Their upper ends are connected with the lower ends of the rafters by tangent curves, which together with a curve at the peak, give the straight rafters somewhat the effect of an arch. The rafters have an 18x40-in. cross section and are reinforced by ten 1-in. bars near the upper surface and ten near the lower surface, as indicated in the cross section detail. The top chord bars are spliced and are made continuous to the feet of the columns. There are also five 1-in. bars making an angle of about 45 degrees with the vertical which extend across the top of each column and the foot of the rafter reinforcing the curved knee brace, and together with the transverse shearing bars are arranged as indicated in the half diagram.

The lower chord bars are in single lengths, extending through both rafters from one knee-brace to the other, and being continuous are curved at the apex of the roof. They terminate 5 ft. from the lower ends of the rafters where a set of five 1-in. bars in the same plane are lapped over them about 5 ft. and continue to the end of the rafter. The bars in the top chord and in the outer face of the column are made in three lengths lapping 33-in. and breaking joints at splices, where they are enclosed by Ransome coil-couplings of ¼-in. steel. The inner faces of the wall columns are reinforced by five vertical 1½-in. bars, which run in single lengths from the footing to the top of the rafter. The reinforcement rods in the columns are connected together by a coil of ¼-in. bar at a pitch of 18 in. which is made continuous by being lapped 12 in. and wired at joints.

The flange bars in the rafters are connected and web stresses are provided for by coils of ¼-in. rods in five sets, connecting the top and bottom pairs of flange rods as shown in the cross section and in the diagram. The pitch of the coils varies from 9 in. at the crown to 18 in. at the haunches and the rods in them are made continuous by lapping 18 in. at joints, where they are wired together. Each coil is given a full turn around the top or bottom pair of bars at every intersection and the latter are fixed in position by spreaders between them at these points.



General Details of the Reinforced Concrete Building of the Northwestern Ohio Bottle Works

The rafters are connected and braced by horizontal longitudinal purlins 4 ft. apart on centers. These have a cross section 2½ in. wide and 18½ in. deep over all, including the thickness of the 2½-in. roof slab. They are reinforced with a single ¾-in. bar 1½ in. from the lower edge, and have ¼-in. vertical bars proportioned in accordance with the shear diagram. At the center points of the panels the purlins are stayed by transverse struts 4 in. wide and 18½ in. deep, reinforced by two ⅜-in. bars in the lower edge. These struts are made in two equal parts with a joint on the center line as indicated in the detail.

The rafters, purlins and struts are all made integral with the roof slab, the latter having no reinforcement bars. All of the angles at the intersection of the roof slab with the purlins and rafters are filleted. In the center of the furnace room there is a monitor four panels long and 20 ft. wide which is also made entirely of reinforced concrete with large window openings in the walls. Its framework consists of vertical posts seated on the special upper purlins and on a longitudinal ridge beam, which carry three lines of longitudinal beams, at ridge and eaves, supporting the roof slab. The latter is 3 in. thick and is reinforced by ⅜-in. bars 7½ in. apart on center parallel with the rafters.

The wall columns have 6 ft. 10 in x 7 ft. 6-in. footings 6 in. deep at the outer edges and 18 in. deep at the center. They are reinforced with crossed layers of ¾-in. bars, 16 in all, 3 in. from the lower surface. The outer or curtain walls are 4 in. thick above the floor line and are reinforced with ⅜-in. horizontal bars 2 ft. apart alternately near the inner and outer faces. There are also single vertical bars at the edges of the door and window openings and wall panels.

The main floor slab is 8 in. thick, and is reinforced by ½-in. bars 5 in. apart on centers. It is carried as indicated in the general cross section by the 9-in. outer walls which are reinforced with 3½-in. bars to form girders over the doorway, and by intermediate 10x19-in. girders from 16 to 19 ft. long, which are reinforced with four 1-in. bars, and connect the tops of one-story interior columns. The latter are 9 and 10 in. square, and are reinforced with four ⅜-in. vertical bars with ¼-in. hoops 24 in. apart. Their footings are flat slabs of uniform thickness and varying dimensions, all of which are reinforced with crossed layers of ½-in. bars.

The 50x48-ft. mixing shed has a flat roof sloping in one direction only and is about 12 ft. high on one side and 14 ft. high on the other side. The 4½-in. roof slab is reinforced with ½-in. bars 9 in. apart and is supported on four longitudinal rows of columns about 13 ft. 5 in. apart transversely and 16 ft. apart longitudinally. The tops of the columns are connected by 10x16-in. intermediate longitudinal girders reinforced with three 1-in. bars. The intermediate columns are

8 in. square at the base and above the floor their corners are chamfered to make them octagonal. Each one is reinforced by 8 ¼-in. vertical bars and hooped by a coil of ½x⅛-in. steel. The wall columns 12 in. square have four ⅜-in. vertical reinforcement frames of ¼-in. steel wired to them 2 ft. apart. The columns are grooved on opposite faces to receive the beveled ends of the 4-in. curtain wall slabs. The tops of the wall columns are connected by irregular girders, integral with the walls, which in some places are provided with solid concrete ridges on the upper surface to prevent the roof water from flowing over the edge of the wall.

The 39x69-ft. coal shed is supported on four longitudinal rows of columns 11½ ft. apart. The columns are 12 in. square and the interior ones have their columns chamfered to make the cross section octagonal. They are reinforced with eight vertical ⅜-in. bars and hooped with a continuous spiral. The tops of the columns are integral with 13x20-in. longitudinal beams reinforced with pairs of 1-in. bars except in the outside lines where ¾-in. bars are used. They are also united by 6x18-in. transverse girders reinforced with pairs of 1-in. bars. Both transverse and longitudinal beams are integral with, and filleted to, the floor slab 6¼ in. thick, which is a continuous mass of concrete made without joints and reinforced ⅝ in. above the lower surface by two cross layers of ⅜-in. bars 4½ in. apart. The upper surface of the slab is finished with 1 in. of cement mortar.

The upper story columns are in the lines of the lower columns but are not integral with them. The interior rows have 9-in. octagonal cross sections and are reinforced with eight vertical rods and hooped like those in the lower story. The upper ends of the columns are connected by 14x18-in. longitudinal girders reinforced with pairs of ¾-in. bars. These carry the 13-ft. panels of 4-in. roof slab pitched slightly to the eaves and reinforced with a single layer of ½-in. bars 9 in. apart. The side walls are from 3 to 6 ft. high and are made with 4-in. slabs of concrete reinforced by ⅜-in. horizontal bars 6 in. apart near the outer face of the wall.

All concrete was made 1:1½:3 with Tiger Portland cement and ¾-in. broken stone mixed very wet in a Ransome mixer. A complete set of moulds and falsework was constructed for the simultaneous execution of all work and none of the moulds were used a second time on this job. In the main building care was taken to fill the moulds for the wall columns continuously up to a point, just above the spring line before concreting was stopped. Afterwards the concreting for the rafters was made continuous from these points on both sides of the building until the rafters were completed, work being carried on simultaneously in the roof of the adjacent building to the right which was made integral with this work up to the first regular joint.

About 1,500 yards of concrete and 85 tons of twisted steel were used and the work was accomplished by an average force of 30 men in 70 days. The buildings were originally planned by Mr. Harry W. Wachter, architect, Toledo, O., with all concrete construction designed by the Ransome & Smith Co., New York. They were erected by The Henry J. Spieker Co., Toledo, O.

STEAM SHOVEL RECORDS at Panama continue to improve, according to a report from Chief Engineer Stevens recently made public by the Canal Commission. A number of the shovels are not working in such a way as to produce a good record, being employed in trimming up the Culebra cut so as to have it ready for service tracks, yet the total number of yards taken out was 168,410, at a cost of 61.8 cents.

Book Notes.

A publication of the U. S. Geological Survey that has proved very useful to engineers is Mr. Henry Gannett's "Dictionary of Altitudes in the United States," a fourth edition of which has just been issued. This is a book of 1,072 pages giving the altitudes of all points in the United States which can be referred to sea level from the available data concerning them. The altitudes are derived from public and private surveys, but mainly from the records of railway companies, which have found the information in the earlier editions of the book particularly valuable and accordingly assist in its compilation by furnishing new data from their lines. Mr. Gannett states that many of the railway profiles are wonderfully accurate, "some comparing favorably even with the precise leveling of the United States Coast and Geodetic Survey and of the river commissions." The data are arranged by States and the authority for each elevation is stated.

One of the most important services ever rendered by the New York Chamber of Commerce was in connection with the solution of the rapid transit problem on Manhattan Island. After the project had engaged the attention of public officials and private citizens for a quarter of a century, the Chamber of Commerce found the solution of the most difficult feature of the problem, how to lend the city's credit to the enterprise without departing from the necessarily limited field within which a municipality is justified in taking a direct interest in the affairs of a private corporation. The Chamber drew the bill that was passed at Albany in 1894, under which work was commenced at last and finally carried forward to completion. The memorial tablet in the City Hall station of the subway states that the road was "suggested by the Chamber of Commerce, authorized by the State, constructed by the City." As a matter of fact this statement does not by any means explain the important part played by the Chamber and its members in the undertaking, and in order that the record of its work may be preserved in a form accessible to everyone, a well written and handsomely published volume has been prepared by Mr. S. D. V. Burr under the direction of a special committee appointed for the purpose. Its title is "Rapid Transit in New York City and in Other Great Cities." Abram S. Hewitt, the father of rapid transit in the city, was a leading member of the Chamber, and six of the eight members of the Rapid Transit Commission have always been members of it. Its chief engineer until recently, Mr. William Barclay Parsons, is not only a member of the Chamber but a direct ancestor obtained the original charter of the Chamber from the British Crown. His testimony to the important work done by Mr. Alex. E. Orr, ex-president of the Chamber, as chairman of the Rapid Transit Commission, deserves printing here: "At many very critical moments, if it had not been for his steadfastness and absolute and unswerving belief in the enterprise of which he was the head, we would not have had rapid transit to-day." Another engineering member of the Chamber has very fittingly stated its reasons for being proud of its connection with this work; Mr. Alfred P. Boller's remarks on this point are as follows: "In its whole history of public accomplishments the Chamber of Commerce never did a greater thing than becoming sponsor for the magnificent system of rapid transit subways with which this city (New York) is now blessed. Great as this achievement has been, it has done even more than create a work of public utility of far-reaching consequences. It has shown how a great public work, of incalculable value to the city of New York for all time to come, can be conceived, organized and carried out free from those political entanglements which so often prove a source of waste, extravagance or scandal." In order that the full measure of what the Chamber accomplished may be understood, this memorial volume not only gives a history of the undertaking and a description of the railway and its future extensions, but also explains the rapid transit facilities in other large cities. In consequence the book is one of the most important histories of urban transit ever published.

Letters to the Editor.

GOVERNMENT SPECIFICATIONS.

SIR: Under the heading, "A Legal Criticism of Goveriment Specifications," an article appears in your issue of March 3, making extensive comments upon the specifications of the Reclamation Service.

The "general comment" at the end of the article is characteristic of the spirit of the criticisms and exhibits a total misconception of the conditions under consideration by comparing Government work with railroad work. Controlling conditions in the two classes of work are radically different. Railroad companies usually make their contracts with reliable, well-tried firms, whose personnel is familiar to them and who can be depended upon to do good work at a reasonable cost without much restriction in the specifications. This policy is utterly impossible in Government work, because the law requires and public sentiment demands that wide publicity and unlimited competition be permitted. The Government specifications, therefore, must be drawn in such a manner as to permit of stringent supervision of the work of unknown, incompetent and rascally contractors who may receive the award by reason of submitting the lowest bid. For this reason it is imperative to close every possible loop-hole for claims for extras by specific provision against such, as some contractors do not scruple to submit false affidavits, to garble oral statements, and to otherwise take advantage of any possibility of squirming out of their contracts if they find them unprofitable, or of piling up bills for extras.

It is not true that "contractors whose reputations assure them of remunerative work for parties on fair terms object to bidding on them." J. G White & Co., Orman & Crook, Geddes & Seerie Stone Co., James O'Rourke & Co., Prendergast & Clarkson, Bates & Rogers Construction Co., and Hubbard & Clarkson, each have one or more contracts with the Reclamation Service, each have bid on several contracts, and, so far as known, none of them has ever criticised or found any difficulty with the standard specifications; and these firms and many others who have bid are in financial standing and efficiency perfectly satisfactory to the engineers of the Reclamation Service. Few if any contractors in the country are more desirable than most of those named in the above list. So far from the specifications adding to the cost of the work, they have been commended by the best contracting firms as being unusually definite and liberal to the contractor when compared with specifications in ordinary use on public works, and the bids received under them have, as a rule, been lower than expected, and in many cases lower than was reasonably desirable in order to allow such profit to the contractor as to make the contract mutually satisfactory to him and to the Government.

In reply to the specific criticisms, I have the following statements to offer:

Definition of Engineer.—This term is defined as "the Chief Engineer of the Reclamation Service or any of his authorized assistants or inspectors limited to the particular duties entrusted to them."

In commenting upon this, the critic says: "The contractor must ascertain at his own peril whether the particular officer is within the limits of his own particular duties." In any business relation, a man transacting business must "at his own peril" make certain of the identity and authority of the person with whom he is transacting business. If contract work can be carried on by ignoring this general principle, it would be interesting to learn this fact. The contractor can know definitely who is authorized to give him orders in each detail of his work by an inquiry, insisting if he chooses upon written orders.

Such written instructions are always given, and the contractor can insist upon receiving a copy of the same. It is entirely proper that he should do this, and it is not clear how the specifications could be modified in any way to simplify this matter, or make it any clearer. The weakness of this criticism would be patent if the critic would endeavor to introduce a satisfactory substitute.

Risk of Conditions.—"Bidders must satisfy themselves as to the nature of the material and as to all local conditions affecting the work, and no information derived from the maps, plans, specifications, profiles or drawings, or from the engineer or his assistants, will in any way relieve the contractor from any risks or from fulfilling all the terms of his contract." The critic interprets this paragraph to mean "after information is thus given them they are told they cannot rely upon it."

I submit that this is an unfair and unwarranted interpretation of the specifications. The available information is given the contractor, who is supposed to be reasonably cognizant of the limitations upon human knowledge and human observation, and he is not told that he cannot rely upon the information. He is simply told that he cannot escape his responsibilities, but must fulfill all the terms of his contract.

This criticism appears to be based upon lack of appreciation of physical investigations, as is proved by the first sentence of the second criticism: "Certainty should always be a feature of contracts."

This is absolutely impossible. If borings are made along a canal line at intervals of, say, 1,000 ft., in order to determine the material to be encountered, this is a reasonably safe indication. The contractor under these specifications is given the data thus obtained, but practically all the information is an inference from these investigations. Certainty is utterly impossible. Even if the borings are only 10 ft. apart (a perfectly absurd refinement) this will leave the material between borings to inference. It is to cover this uncertainty that excavation work is paid for under classification by the cubic yard, instead of payment being made in lump sum for the whole work. When the contractor has received the results of the Government's investigation, he cannot complain of assuming more than his share of the risk.

If this is a just complaint, the entire contract system must fall to the ground, and work must be done by force account or by the method of cost plus a fixed amount, which is not adapted to Government work.

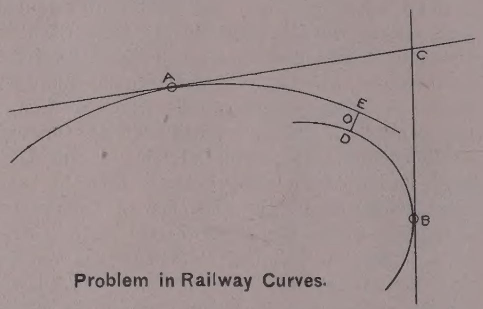
The specification referred to is entirely misinterpreted in the statement that the "specifications attempt to throw on the contractor all the responsibility for preliminary work of the Government." The restriction referred to merely operates to prevent dispute and claims for extras on the part of the contractor by accurately defining responsibility for uncertainties.

The Government's Delays.—"The contractor shall not be entitled to any compensation for delays or hindrances to the work for any cause whatever." The plain inference from the above and from the criticism that follows is that the specifications provide for rigidly carrying out the terms of the contract regardless of any delays caused by the Government. This is a garbled and unwarranted construction of the specifications, as is shown by reading the balance of the paragraph, which says: "Extensions of time will be allowed for unavoidable delays, such as may result from causes which, in the opinion of the engineer, approved by the Secretary of the Interior, are undoubtedly beyond the control of the contractor."

The Government is more interested in the early completion of work than is the contractor. It may be reasonably inferred, and is in fact the case, that the Government will not deliberately and in any manner which can be avoided delay the contractor, but if it does it promises him an extension of time equivalent to such delay, and these extensions have always been liberally granted. The provision criticised is to prevent the accumulation of claims from alleged causes of delay, which unreliable contractors are prone to make.

If money payment for delays is to be made, some provision regarding the damage is necessary, and the entire matter will be so complicated as to be impossible of adjustment. So far as known no contractor has ever considered this specification a hardship.

Changes.—"The Secretary of the Interior reserves the right to make such changes in the specifications of work or material at any time as may be deemed advisable, without notice to the sureties or surety on the bond given to secure compliance with the contract, by adding thereto or deducting therefrom, at the unit price of the contract, or at such allowances for changes of materials as shall be deemed just and reasonable by the engineer, whose decision shall be binding on both parties."



Problem in Railway Curves.

The critic says "there should be no material variations from the quantity of the work to be done. Particularly there should be no diminution of it, because in constructing work in a remote part of the country a very large outlay must necessarily be made," etc.

The total ignorance of physical conditions to be met with in many classes of construction is shown in this criticism that "there should be no material variations from the quantity of work to be done." This is as absurd as it is impossible. To cite a single instance, it is impossible to estimate in advance accurately the quantity of earth to be moved in building a canal on a mountain side.

The critic properly says that the quantities are never to be diminished. Adhering to this rule, the engineer may assume the side slopes of his canal to be 1 to 1, and when the ground is opened up to some depth, it may be and often is found that the character of material is such that it will stand permanently only on a much flatter slope. On a steep side hill this will throw the top of the upstream bank possibly 100 ft. higher than the original estimate provided for, and very largely increase the original estimates.

As the contractor is paid by the cubic yard there is, or should be, no embarrassment from this cause, for if he is an intelligent man he will understand the necessity of these variations and estimate accordingly. It would be unwise to in any way limit the elasticity of such matters.

The criticism on this point, like all the others, is unfair in that the critic offers no substitute. If he will do so, it would be easy to show the fallacy of his argument.

Formation of Embankments.—"Earth and all embankments should be deposited with scrapers unless special permission is given by the engineer to use another method." Like some of the other criticisms, the quotation does not give a correct idea of the requirements of the specification referred to. The paragraph from which this sentence is taken is very long, and describes in detail the character of the work required and definitely specifies how this *can* be done, namely by scrapers used in a certain way. In order to leave more latitude for discretion to the contractor, the engineer may allow any other method that will accomplish approximately the same result. The spirit of the entire paragraph is to allow the widest possible latitute to the contractor, simply holding him responsible for results, which must be left to the judgment of the engineer. Unnecessary restrictions upon the contractor regarding his methods are productive of friction and expense and are unwise.

No claim is made that the specifications are perfect; and if any of the objections raised can be removed by changes which will not imperil the public interests, suggestions for improvement will be gladly received.

Very truly yours, A. P. Davis,
Washington, March 14. Asst. Chief Engr.

A Problem in Railway Curves.

Sir: Can you obtain for me a solution of the following problem? It is one that would often be of use to me in running in spiral alignment between the branches of a compound curve. Given two curves of different radius of which the sharper curve is within the other. If, from any points, A and B, on both curves tangents are run to an intersection at C, and the length of these tangents AC and BC, and the angle of intersection at C are measured, how, from these data, can I calculate the lengths of curve AE and BD from the points of tangency to the point where the curves are parallel, and also the perpendicular offset O between curves at that point?

Yours truly, Subscriber.

Grade Stakes.

Sir: In your issue of March 10 I note a letter on the checking of grade stakes, and a comment which gives an extract from a letter from Mr. James Dunn, and another from a letter from Mr. E. J. Beard, which, according to the comment, show opposite views. That opposite views on this question may be held by these gentlemen is possible, but do the quotations show it? According to the experience of the writer the statements of both men are entirely correct. The checking of levels on railroad location is "customary and important," but this does not mean the checking of grade stakes, which are usually set after the location levels have been checked, often at the time of checking the location levels, but not until these levels have been checked. Of course, if both men are referring to the same operation, their views are opposite, but the language used leads one to believe that they are referring to two distinct operations.

Iowa City, Ia. Wm. G. Raymond.

A Smoke Consuming Device, invented by Mr. George M. Boone, chief engineer of the Johns Hopkins University buildings, has been installed in a number of boilers of different types in that city, including all at the university. It is described as a stationary deflector, attached to the furnace door or other convenient place, which sets up a whirling motion of the gases and air in the fire-box and causes an early and intense heat, thereby preventing the scape of unconsumed gases and soot.